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APPLIED MECHANICS REVIEWS

VOL. 6, NO. 3 **MARTIN GOLAND** *Editor* MARCH 1953

THEORY OF THE FLOW OF INCOMPRESSIBLE INVISCID FLUIDS

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THE intention of this report is to mention briefly some of the salient features of progress from 1946 onward. Inevitably the judgment of the writer will not always coincide with that of the reader who is asked to attribute omissions in the bibliography rather to ignorance than to undervaluation.

Although transcending the limitations of the title of this article, it seems appropriate to refer to four fundamental papers by Born and Green (1946, 1947) on the general kinetic theory of liquids, in which, inter alia, generalized hydrodynamical equations are derived and it is shown that the various quantities of interest, pressure tensor, energy flux vector, coefficient of viscosity, etc., are the sum of two parts. One part arises from the thermal motion and the other from the molecular forces. For a gas the former, for a liquid the latter is dominant.

GENERAL PRINCIPLES

Davidov (1949) gives a new variational principle in which the variables are the displacements of fluid particles from positions of initial rest. Manwell (1949, 1952) considers the determination of the boundary conditions to minimize a functional of both boundary and velocity in two-dimensional flow past an obstacle. Kilmister and Chirgwin (1949) obtain a tensor integral from which minimum energy theorems can be inferred. Calling a flow unique when the only flows with the same streamline pattern have velocity fields simply proportional to that of the given flow, Prim (1949) proves that all irrotational flows are unique except helicoidal flows obtained by superposition of a uniform stream and a potential vortex.

WAVES

As might be expected, considerable progress has been made in elucidating problems in the linearized theory when plane barriers are present. The "exact" linear theory which neglects the second-order terms only in the boundary conditions has been applied to waves on a sloping beach. The motion of floating and submerged bodies has received attention. Of particular interest is Havelock's (1949) second-order approximation to the resistance of a submerged cylinder in accelerated motion. Significant progress has been made in the nonlinear theory of waves of finite amplitude. Sekerzh-Zen'kovich (1951), computing to the third power of a parameter, finds that for standing waves on the free surface of water of infinite depth there exist summation and difference waves representing action between linear waves; there are no fixed nodes and the surface is never completely flat. Penney and Price (see Martin and others, 1952) have also considered this problem for water of finite depth. Davies (1951, 1952) and Packham (1952) have treated the problem of gravity waves differently; namely, by replacing Levi-Civitá's nonlinear boundary condition by another nonlinear boundary condition which preserves the essential features of the original one and for which an exact analytical solution can be obtained. This method, in its first approximation, makes it possible to discuss all waves from those of small amplitude to those which are on the point of breaking at the crest. This work constitutes a notable advance.

VORTICITY

Defining total vorticity as the volume integral of the vorticity vector, Truesdell (1948) develops some new theorems. He also (1951) establishes a purely kinematical vector theorem which includes known vortex laws and leads to important extensions. Synge (1949) enumerates the configurations of three vortices, and Fabbrichesi (1948) finds the necessary and sufficient conditions of stability for four vortices at the vertices of a rhombus. In a series of papers, Dolapchiev (1949, 1951) discusses the stability of vortex streets, and Coddington (1952) gives the treatment in terms of the full infinite system of equations for small displacements. The semi-infinite street is investigated by Cârstoiu (1948). Goldstein and Lighthill (1950) show that the hodograph plane corresponding to a circular cylinder in uniform shear flow is a six-sheeted Riemann surface which verifies previous results of Craggs; e.g., the folding back of the hodograph plane along branch lines, and that the branch lines are usually cusped. The plane nonuniform movement of one and two plates with trailing vortices is investigated by Vladimirsky (1950).

FREE STREAMLINES

The idea of free streamlines separating from a body exposed to a stream, and departing to infinity to enclose a wake of deadwater goes back to Helmholtz and Kirchhoff. In recent years this process has attracted important investigations. The deadwater wake is physically unrealistic, but cavity flow in which the region is occupied not by water but by water vapor or air is a recognized phenomenon which has many applications. The importance of the ratio of the densities within and without the cavity was pointed out by Birkhoff (1948). For a deadwater wake this ratio is 1.00, while for a cavity it is of the order 0.001. The mathematically simplest cavities are those extending to

infinity, but recently cavities closing to form a cusp, Allen, Lighthill (1949), and cavities with re-entrant jet, Èfros (1948), Gilbarg and Serrin (1950) have been examined. Von Kármán (1949) and Gilbarg (1952) give instances of accelerated flow with attached cavities. The determination of free streamlines by analytical continuation across them is treated ingeniously by Shiffman (1948, 1949). Wall effects on cavity flow are discussed by Birkhoff, Plesset, and Simmons (1950, 1952). Important existence and uniqueness theorems are given by Gilbarg and by Serrin (1952).

AXIAL SYMMETRY

Flows due to rings and disks of sources are studied by Weinstein (1948) and, with the aid of elliptic integrals, by Sadowsky and Sternberg (1950). The source disk in a stream is used by Van Tuyl (1950) to generate a new series of half bodies. Power (1951) gives a general theorem (not confined to axial symmetry) of the change in potential due to a dielectric sphere. For zero specific inductive capacity, this yields Weiss' sphere theorem. A new and promising method is given by Rose (1950) who uses the theory of analytic functions of a quaternion. This method is analogous to the complex variable treatment for plane flows.

OTHER TOPICS

Among the many other problems of recent years, the impact of bodies on a water surface is discussed by Trilling (1950) for certain bodies half-immersed, and by Shiffman and Spencer (1951) for the vortical entry of a cone. (For cases of the subsequent motion with cavity, see under Free Streamlines.) Some attention has also been given to virtual mass. Pólya (1947) proves that of all cylinders of the same cross-sectional area, the circular cylinder has the least average virtual mass per unit height, and conjectures that the sphere has minimum virtual mass for given volume. This conjecture is confirmed by Szegö (1949). Jacobsen (1949) opens up a new branch of fluid dynamics in considering the forces exerted by the water on a partly filled cylindrical tank and upon a pier surrounded by water in the case of an earthquake. Utilizing the asymptotic properties of Bessel functions, he obtains good agreement with experiments.

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(See also Revs. 721, 733, 752, 755, 757, 758, 790, 871, 962, 975, 981, 982, 1059, 1069, 1097, 1102)

694. Bowker, A. H., and Goode, H. P., Sampling inspection by variables, New York, McGraw-Hill Book Co., Inc., 1952, xi + 216 pp. $5.

In 1948, the results on attribute sampling obtained during World War II by the Statistical Research Group at Columbia University appeared in book form in the McGraw-Hill publication, "Sampling inspection," edited by H. A. Freeman, M. Friedman, F. Mosteller, and W. A. Wallis. The present book is, in a sense, a companion volume. Essentially, it has the same general objectives of the 1948 book, except that the authors are concerned with sampling by variables rather than by attributes.

In attribute sampling one can only say about each item in the sample that it either conforms to some specification or it does not. In variables inspection one actually makes a measurement on each item in the sample. Clearly, the latter procedure is more informative than the former. Consequently, it seems most reasonable that a decision procedure which carries with it certain

risks of making wrong decisions can be attained with smaller samples if variables rather than attribute sampling is used. As to whether or not a variables plan should be used in preference to an attributes plan depends on many factors, only one of which is the fact that the sample sizes in variables plans are substantially smaller than those using attributes. If gaging is very expensive and time-consuming, for example, it might be well to stick to using attributes. Also, the computations required to make a decision on the basis of actual measurements are generally more involved than the counting processes involved when attribute sampling is used. An intelligent choice between variables and attributes can really be made only after the various costs involved in the inspection process are taken into account.

The main feature of the book is an excellent set of variables tables and their associated operating characteristics. The tables are catalogued in such a way that the user can readily pick out the plan which will give him good protection against the twin evils—rejection of good lots, and acceptance of bad lots. Both single and double sampling plans are given. Sequential sampling is not treated because of both practical and theoretical difficulties associated with constructing standard sequential plans.

It should be noted that the underlying assumption made throughout the book is that the characteristic being measured is normal. The authors state that this may be an unrealistic assumption and that, when deviations from normality are marked, the tables are invalid. Of course, the whole question of what to do under conditions of non-normality is one which has worried both the theoretical and practical statistician for a long time. A substantial body of experience built up during the past few years by various users of quality-control and sampling-inspection techniques seems to justify the pragmatic rule that the normal distribution works fairly well in many cases. However, there will be situations from time to time when non-normality of the underlying distribution is very marked. In such circumstances, the tables in this book should not be used.

Sampling plans are given for situations where the standard deviation is known and when it is unknown. The same O.C. curve can be obtained with a much smaller sample size if the standard deviation is known than if it is unknown. In fact, throwing away the information that the standard deviation of a process is known, and treating it as if it is unknown, will involve using samples which are too large and will consequently give tests which are too stringent. Procedures for handling both one- and two-sided specification situations are given. Chapter 11 of the book contains much valuable new theoretical material connected with the mathematics of sampling inspection by variables.

The book is a useful addition to the growing list of publications aimed at meeting the needs of the industrial statistician.

Benjamin Epstein, USA

695. Goulden, C. H., Methods of statistical analysis, 2nd ed., New York, John Wiley & Sons, Inc., 1952, vi + 467 pp. **$7.50.**

Applied statistics is important for research engineers in a wide variety of fields, particularly in design and analysis of experiments, in quality control for the manufacturing industry, in taking samples, and in deducing empirical laws. · This book is very valuable for research work; clear statement of fundamental principles, various worked examples, and convincing logic assure that it will be one of the most popular books in applied statistics. Concisely, the book contents are: Frequency distributions; test of significance; analysis of variance; regression analysis, correlation, covariance. Basic experimental design, factorial experiments, lattices. Quality control and sampling. For the first time in one book are given modern methods of computation for partial and multiple correlation, factorial and incomplete block experiments, nonorthogonal data, and probit analysis. In comparison with first edition (1939), this is completely revised and enlarged from 277 to 467 pages, and can, therefore, be rather regarded as a new book.

Steponas Kolupaila, USA

696. Fox, L., Escalator methods for latent roots, *Quart. J. Mech. appl. Math.* **5,** part 2, 178–190, June 1952.

In "escalator method" for determining latent roots and vectors of a matrix, solution is obtained in stops, the roots and vectors of complete matrix of order n being obtained from those of a leading minor of order $m(<n)$. Author gives a concise and comprehensible presentation of theory of p-step escalator process in which minor is increased by any order p. New results include a useful iteration for computing successive latent vectors. Backward escalator, where latent roots and vectors of minors are found from those of complex matrix, is also treated. In treating $(A - B\lambda)x = 0$, where A and B are symmetric, alternative is suggested to usual procedure of reducing to standard case by premultiplying with B^{-1}. Author's method depends on resolution of B into product of upper and lower triangular matrix whereby symmetry is retained. Method offers much the same computational advantage author has demonstrated it to have in inversion of matrixes.

C. C. Gotlieb, Canada

697. Salles, F., and Thorn, C., Method of finite differences applied to two-dimensional problems of calculation of stresses in a plate (in French), *Publ. sci. tech. Min. Air, Paris,* BST 115, 85 pp., 1951.

The finite difference procedure for the solution of two-dimensional stress problems in terms of Airy's stress function is developed. Difference equations are derived in detail and conveniently compiled for application. Finite difference expressions of first-order approximation are given for various boundary nodes. Two applications were made to the problem of a plate subjected to (a) parabolic tensile forces over two opposite edges, and (b) compressive forces across one edge and shear forces on the two adjacent edges.

The work is not new. However, it is a simple, direct treatment of the subject useful to one wishing to solve stress problems numerically.

E. D'Appolonia, USA

698. Slobodyanskiĭ, M. G., Determination of derivatives of unknown functions in the solution of problems by the method of finite differences (in Russian), *Prikl. Mat. Mekh.* **15,** 2, 245–250, Mar./Apr. 1951.

In certain problems requiring the solution w of a partial differential equation, the desired quantity is not w itself but one or more partial derivatives of w. When an approximate solution is obtained by the use of a lattice and a difference equation, the derivatives can be found by difference formulas, but the degree of accuracy is less than for w itself. The author shows how to set up partial differential equations satisfied by the desired derivatives and which can be solved, for a given lattice, to the same degree of accuracy as the equation for w. The idea is applied to the torsion of a rod of square cross section, and to the case of a square loaded plate.

Courtesy of Mathematical Reviews W. E. Milne, USA

699. Swenson, G. W., Jr., and Higgins, T. J., A direct-current network analyzer for solving wave-equation boundary-value problems, *J. appl. Phys.* **23,** 1, 126–131, Jan. 1952.

The numerical solution of the two-dimensional wave-equation boundary-value problem may be obtained at the intersections of a regular rectangular grid by relaxation methods. Values of solu-

tion at the finite number of points in the grid are obtained by solution of a set of linear algebraic equations. The analogy between these equations and the Kirchhoff equations for the voltages at nodes of d-c network is developed. The load resistors at the nodes adjacent to the boundary are shown to be positive, while interval nodes require negative resistors to ground. Negative resistors are simulated by simple active circuits. These must be adjusted in an iterative manner. The values of the resistances for a given system depend on the frequency of the assumed disturbance. Steady-state responses to sinusoidal forces may be obtained by applying currents, which simulate the forces, at desired joints. The iterative adjustment of the negative resistances converges at frequencies from zero through the first resonant frequency and almost up to the first antiresonant frequency. The resonant (first characteristic) frequency may be obtained by applying constant voltage at a node and varying the assumed frequency (i.e., values of resistors). By interpolation, the resonant frequency is obtained as that which gives zero current in the battery applying the disturbance. Methods are discussed for application to inhomogeneous or anisotropic media and various types of boundary conditions. A. A. Schy, USA

700. **Coddington, E. A., and Levinson, N., Perturbations of linear systems with constant coefficients possessing periodic solutions,** Contrib. Theory Nonlinear Oscill. **2**, Annals Math. Studies no. 29, 19–35, 1952. $1.50.

A mathematical study is presented of a problem in the theory of nonlinear oscillations. It deals with nth-order linear constant differential systems which are perturbed by slight nonlinearities. They may also be excited by weak impressed forces and may contain periodic coefficients which are small and of the same order as the other perturbations. It is assumed that the unperturbed system has a periodic solution of known frequency. The problem is that of establishing a set of sufficient conditions for the existence of periodic solutions in the perturbed system. It is specified, however, that the conditions should apply in those cases in which a commonly used condition fails; i.e., when a certain Jacobian connected with the system vanishes.

Two subcases are distinguished. In the first, small periodic impressed forces and/or periodic coefficients are assumed to be present with periods which are the same as that of the unperturbed system. A set of sufficient conditions is established for the existence of a harmonic or subharmonic solution. The solution, under slightly narrower conditions, is expressible as a power series with periodic coefficients which can be uniquely determined by a recursion process. In the second case, time is assumed not to enter the system explicitly. Sufficient conditions are stated for periodic solutions with periods near that of the unperturbed system. A group of theorems is derived, paralleling that of the first case. Four rather general examples are given, illustrating the method. R. Drenick, USA

701. **Dengler, M. A., Goland, M., and Luke, Y. L., Tables of the functions** ${}_0\int^y (e^{iu} - 1)\,(u^2 + b^2)^{1/2} du/u$, Midwest Res. Inst., Kansas City, Mo., 20 pp., Aug. 1952.

702. **Kleinschmidt, B., Dictionary of grinding and polishing terms [Wörterbuch der Schleif- und Poliertechnik], Part I. German-English, Part II. English-German,** Berlin, Techn. Verlag Herbert Cram, 1952, 94 pp., 25 figs. DM 9.80.

703. **Bergman, S., On solutions with algebraic character of linear partial differential equations,** *Harvard Univ. Div. Engng. Sci. tech. Rep.* 12, 46 pp., 1950 = *Trans. Amer. math. Soc.* **68**, 461–507, 1950.

704. **Lefschetz, S., Notes on differential equations,** Contrib. Theory Nonlinear Oscill. **2**, Annals Math. Studies no. 29, 61–73, 1952. $1.50.

Author gives an elegant topological analysis of critical points of a real system of differential equations of the form $\dot{X} = P(x, y)$, $\dot{Y} = Q(x, y)$. P and Q are restricted to the class of analytic functions. Critical points treated are further restricted to be "isolated."

Terminology used replaces usual "singular point" by "critical point," and "trajectory" by "path." Fundamental theorem proved in paper asserts "every path in the plane (except the origin) tends toward the limit cycle."

Proof of the theorem depends upon two basic lemmas; the first is a representation lemma, the second is purely topological. Specific application of the basic lemmas is made to the well-known equation of Van der Pol. J. J. Brandstatter, USA

705. **Novozhilov, V. V., On an approximate method of solution of boundary problems for ordinary differential equations** (in Russian), *Prikl. Mat. Mekh.* **16**, 3, 305–318, May/June 1952.

Given the differential equation $L(y) + f(x, y) = F(x)$, with two-point boundary conditions at a and b, L being a linear differential operator, the author seeks a suitable y_1 for starting the iteration $L(y_{i+1}) = F(x) - f(x, y_i)$, assumed convergent. He takes $y_1 = a_1\varphi_1(x) + \ldots + a_m\varphi_m(x)$, with convenient φ's, determining the a's to minimize the integral square of $y_2^{(k)} - y_1^{(k)}$, for whatever k is deemed appropriate to the problem. Admitting the lack of rigorous justification, author comments that "if one speaks not of the exception, but of the rule, the considerations adduced above appear sufficiently convincing," and works out three numerical examples. A. S. Householder, USA

706. **Lanczos, C., Solution of systems of linear equations by minimized iterations,** *J. Res. nat. Bur. Stands.* **49**, 1, 33–53, July 1952.

A general method [reported in AMR **4**, Rev. 2339] for obtaining the eigenvalues and eigenvectors of a matrix by a successive algorithm is specialized to the very important problem of solving a large system of linear equations.

The principles used in this problem are also applied to the problem of determining the eigenvalues and eigenvectors of a matrix by a method which allows the investigator to pay particular attention to large or small eigenvalues or to both. The methods described seem to the reviewer to be much more adaptable to the examination of large eigenvalues, as, in that case, one is able to use a constant machine routine; however, the method described for determining small eigenvalues would certainly prove to have advantages over most existing methods.

Reviewer feels that the peculiarities of a particular problem should determine what method of solution should be used, and that, though Lanczos' methods will be the best available for most problems, they are not in such a form that they will be best for all problems of this nature. K. M. Siegel, USA

707. **Amerio, L., Stability questions in mechanical and electrotechnical problems** (in Italian), *R. C. Sem. Mat. Fis. Milano* **21** (1950), 82–89, 1951.

The stability of a system characterized by the equation $x'' + ax' + b \sin x = c$ is discussed by means of the theory given by Poincaré. After summarizing the essential part of this theory (singularities of the differential equation), the conclusion is reached that the present differential equation has no closed integral curves in the (x', x)-plane. Plotting the curve of stationary speed helps in deciding easily whether the motion belonging to given initial conditions is stable or unstable.

The Poincaré method has been applied before to nonlinear systems by H. Bilharz [*ZAMM*, 206–215, 1942].

G. W. Braun, USA

708. Deverall, L. I., Normal transforms, *Studies appl. Math.*, no. 2, Univ. Utah, 17 pp., Oct. 1951.

Author defines six finite transforms whose kernels are the functions describing the normal modes of transverse vibration of an elastic beam of finite length. The inversion theorems for, and the principal properties of these transforms are listed, and their usefulness in the solution of boundary-value problems is illustrated by applying them to a vibrating-beam problem and a problem on the symmetrical bending of circular cylindrical shells. Useful tables of the normal functions, characteristic values, and transforms of the fourth derivative of a function are given for all six transforms in an appendix.

I. N. Sneddon, England

709. Benscoter, S. U., and MacNeal, R. H., Introduction to electrical-circuit analogies for beam analysis, *NACA TN* 2785, 48 pp., Sept. 1952.

An explanation of the electrical-circuit analogies for the calculation of stresses and deflections of beams is presented in an elementary manner. Analogies are given for beams in bending and torsion with static loads, and in vibrational motion. The paper is written to enable a structural engineer to understand the process whereby an analogous circuit is designed.

G. V. R. Rao, USA

710. Berghuis, J., A class of entire functions used in analytic interpolation, *Comput. Dept. Math. Centre, Amsterdam Prel. Rep.* R 143, 13 pp., 1952.

Report deals with some properties of the functions $F_k(t, u)$ defined by: $F_k(t, u) = \sum_{n=-\infty}^{\infty} e^{-t\pi(u+n)^2} [\sin \pi(u + n)/\pi(u + n)]^K$, k being a nonnegative integer.

From author's summary

711. Goldstein, S., On diffusion by discontinuous movements, and on the telegraph equation, *Quart. J. Mech. appl. Math.* **4,** part 2, 129–156, June 1951.

Author investigates the discontinuous motion of a particle (considered first by G. I. Taylor, *Proc. Lond. math. Soc.* **20,** 196–212, 1921) moving along a straight line by steps of equal duration τ; the velocity (uniform during each step) takes only two values, $+v$ and $-v$; at the end of each step there is a probability p that the particle will continue in the same direction, and a probability $q = 1 - p$ that it will reverse its motion. The probability $\gamma(n, \nu)$ that at the end of the n^{th} step the particle will be at distance $\nu v\tau$ from the origin is computed; it is pointed out that $\gamma(n,\nu)$ could be expressed in terms of hypergeometric functions. Various asymptotic expressions of $\gamma(n, \nu)$ are given; special attention is paid to the following: $n \to +\infty$ with $\tau = t/n$, $\nu = ny/v\tau$, $p/q = n2A/t$ (y, v, t, A fixed); the probability that the particle will be at distance y at time t is 0 if $y > vt$ and $1/2e^{-t/2A}$ if $y = vt$; for $0 < y < vt$ there is a probability density $\sigma(y, t)$ which is a particular solution of the telegraph equation

$$\sigma_{tt} + 1/A\,\sigma_t = v^2\sigma_{yy}$$

Author suggests that this limiting case has a physical meaning as a diffusion process; obviously, the substitution of a hyperbolic telegraph equation for the classical parabolic Fokke-Planck equation will give quite a new shape to the diffusion theory; but to the reviewer the real meaning of the limiting process does not seem quite clear, especially the interpretation of the velocity v.

J. Kampé de Fériet, France

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 728, 729, 730, 741, 753, 916)

712. Synge, J. L., On a case of instability produced by rotation, *Phil. Mag.* (7) **43,** 342, 724–728, July 1952.

Starting with stability criterion given by Routh, author estimates probable characteristics and relative relations between parameters of curious and anomalous toplike toy which departs from its position of static equilibrium when given sufficiently high rate of spin.

Leonard Becker, USA

713. Bucerius, H., The free fall on the rotating earth (in German), *S. B. math.-nat. Kl. bay. Akad. Wiss.* 1950, 77–83, 1951.

Let ω be the constant angular velocity of rotation of a sphere with radius R about an axis through the center, and let at a point of this sphere with latitude φ be given a rectangular coordinate system (ξ,η,ζ), rigidly connected with this rotating sphere and having the following orientation of the axes: ξ-axis is directed to the south along the meridian, η-axis direction is eastward along the parallel, both tangential to the sphere, and ζ-axis direction is vertically upward to the zenith. Then the well-known equations (E) for the relative motion with respect to the $\xi\eta\zeta$-coordinate system can be written down.

In the application to the earth, owing to its oblate shape (geoid) due to rotation, the constant terms containing the factor $R\omega^2$ must be omitted in these equations (E) and $-g$ replaced by $-\bar{g}$, the acceleration due to the resultant of gravitation and centrifugal force caused by rotation of the earth.

Usually, the equations (E) are integrated under the simplifying assumption that the centrifugal terms, containing ω^2 and small in comparison with the Coriolis force, are omitted. Author shows that these equations are also strongly integrable when the centrifugal terms are retained. The integration is accomplished with the initial conditions corresponding to free fall at height h. Since ωt is usually very small (of the order of time of fall/day), the coordinates ξ, η, and ζ can be developed in power series of this small quantity. Comparison with the corresponding formulas of the approximate integration show that the differences are, as it is natural to expect, second-order terms in ω. The correction term containing the factor $h\omega^2$ is missing in the expression for η (deviation to the east) in the approximate integration. This strong solution may be of practical interest for motions in constant gravitation fields when the time of fall t is an appreciable fraction of a day (rockets).

The strong solution of the motion in constant gravitation fields is also given for more general initial conditions.

E. Leimanis, Canada

714. Abramson, H. N., Comments on "Remarks on dynamic loads in landing," *J. aero. Sci.* **19,** 9, p. 639, Sept. 1952.

Concerns paper reviewed in AMR **5,** Rev. 2263.

715. Meriam, J. L., Mechanics, Part 1. Statics, Part 2. Dynamics, New York, John Wiley & Sons, Inc., 1952, ix + 340 pp., xiii + 331 pp. $4, $4.

These elementary texts conform to American engineering school practices. Printing and illustrations are excellent, and the text gives an impression of unusual care and intelligence in preparation and checking. Unlike most recent authors whose pedagogic methods (such as division of subject matter into standardized classifications complete with standard solutions) seem directed to enabling mediocre students to pass standardized tests, author seems chiefly concerned with teaching simple, basic principles and their universal applicability.

A common introduction to each volume includes discussion of accuracy requirements, units, and a brief discussion of dimensional analysis which seems both too incomplete and too advanced to be anything but confusing. The introduction also includes Newton's laws, but no attempt is made to base the methods developed firmly upon them or, for that matter, upon any other set of axioms. As in most texts, there is not much attempt at logical development, such as coordination of treatment of the concepts of centroids and resultants, or of internal forces and bending moments. L. H. Donnell, USA

716. **Chaplígin, S. A., Collected works, vol. I. Theoretical mechanics. Mathematics [Sobraniye sochineniĭ, t. I. Teoreticheskaya mekhanika; matematika]**, Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1948, 484 pp.

The papers on theoretical mechanics contained in this first volume belong to the scientific activities of the author for the period 1894–1912. They concern nonholonomic dynamical systems (4 papers), motion of a rigid body about a fixed point (5 papers), motion of a solid through a liquid (4 papers), and some general problems of theoretical mechanics (1 paper). Some of the material of these papers has been incorporated into the more comprehensive textbooks on theoretical mechanics and has become classical.

Two papers on mathematics belong to the 1920's and deal with methods of approximate integration of differential equations. Five posthumously published papers on various subjects of mechanics conclude the volume. S. A. Chaplígin was born April 6, 1869 and died October 8, 1942. E. Leimanis, Canada

717. **Reeb, G., Remarks on the existence of periodic motions of certain dynamic systems** (in French), *Arch. Math.* **3**, 1, 76–78, June 1952.

Certain second-order ordinary differential equations with periodic forcing function are known to have periodic solutions of the same period. Author demonstrates the existence of periodic solutions for nearly periodic forcing functions, i.e., functions which remain sufficiently close to a periodic function.

C. Ablow, USA

718. **Strecker, F., Practical investigation of stability by means of locus curves and numerical methods [Praktische Stabilitätsprüfung mittels Ortskurven und numerischer Verfahren]** (in German), Berlin, Springer-Verlag, 1950, xi + 189 pp. DM 18.

Book is mainly concerned with the stability of physical systems, governed by a set of ordinary linear differential equations with constant coefficients and with respect to time as independent variable. The first part deals with physical fundamentals and with stability criteria. The second gives practical examples of part one, and the third discusses some extensions to nonlinear systems.

Two methods for investigating stability characterize the book: (1) Consideration of the entire diagram of the frequency-response function $f(i\omega)$, or the like, in the complex plane; $f(i\omega)$ is also studied for nonreal values of ω, and even a method of measuring $f(i\omega)$ in such cases is proposed. (2) Extrapolation of a given part of the mentioned diagram by polynomials and by continued fractions so as to find stability information. Author takes all practical examples and a great part of his language from the field of electronics. He also introduces far more than fifty new notations and definitions which, in reviewer's opinion, are mostly superfluous and confusing for the reader. Author states in his introduction that it did not seem reasonable to him to deduce the subject of his book from definitions, which are as sharp as possible. Hans Bückner, Germany

719. **Starzhinskiĭ, V. M., On the stability of unsteady motions in a certain case** (in Russian), *Prikl. Mat. Mekh.* **16**, 4, 500–504, July/Aug. 1952.

Study of the stability of

$$\dddot{x} + p\ddot{x} + q\dot{x} + rx = 0 \qquad [1]$$

where $p(t)$, $q(t)$, $r(t)$ are between two positive limits l and L, m and M, n and N. [1] is replaced by

$$\dot{x} = y,\ \dot{y} = z,\ \dot{z} = -rx - qy - pz \qquad [2]$$

and stability of [2] is discussed by the second Lyapunov method and a positive definite quadratic form. S. Lefschetz, USA

720. **Sieker, K.-H., Four-bar linkage as function generator. Analytic representation of Burmester's circle-point and center curves** (in German), *Feinwerktech.* **56**, 6, 182–187, June 1952.

Problem is to determine dimensions of four-bar linkage for a desired functional relation between crank-rotation angles. Author selects four correlated pairs of crank positions and derives expressions for corresponding Burmester circle-point and center curves. The remaining independent parameter can then be assigned several values, and corresponding linkage dimensions calculated. The different designs so obtained can then be evaluated by comparing generated functions with the desired function.

A. S. Hall, USA

721. **Peres, N. J. C., Nomogram for mean radius of curvature of helical tooth flanks**, *Engineering* **174**, 4517, p. 235, Aug. 1952.

Given normal pressure angle and spiral angle at pitch radius, nomogram enables determination of radius of curvature at pitch line assumed to be mean radius of curvature. Same nomogram gives base-cylinder spiral angle and pitch-line transverse pressure angle. Author has unfortunately added to the confused symbols of the literature by using neither U.S. nor British standard symbols; e.g., suffix o for pitch-line dimensions.

Ewen M'Ewen, England

722. **Dengler, M., Goland, M., Herrmann, G., A bibliographic survey of automobile and aircraft wheel shimmy**, *Wright Air Develop. Center, WADC tech. Rep.* 52-141, 142 pp., Dec. 1951.

A literature survey, including 314 references, is presented for the fields of automobile and airplane wheel shimmy. In addition to the bibliographic listings, a short review and appraisal of the contents of each reference are given.

The report contains indexes according to subject, author, and nationality of the contributions; the periodical coverage of the survey is also given in detail. A general survey of the problems of automobile and airplane wheel shimmy is included, which highlights the principal trends and contributions to the subject over the years. Finally, on the basis of the survey indications, recommendations are advanced for further research and development in the field. From authors' summary

723. **Yudin, V. A., Certain questions in the dynamics of mechanisms with higher pairs, allowing for friction** (in Russian), *Trudi Sem. teor. Mash. Mekh.* **10**, 38, 5–26, 1950.

The author is interested in the equation of motion of the (rotary or translatory) driving member of a plane cam mechanism. It will be sufficient here to consider the rotary case. If the equation is written in the usual form, $\frac{1}{2}d(I\dot{\phi}^2)/dt = M$, where I and M are the "reduced moment of inertia" (variable) and the "reduced torque load." The paper claims, in the essence, that the effect of friction can be accounted for by putting, in the

general case of k cams and negligible inertia forces (but not moments)

$$I = I_1 + \Sigma_{j=2}^{k} I_j(i_{21}i_{32} \ldots i_{j,j-1})^2/(\eta_1\eta_2 \ldots \eta_k)$$

and doing the same for the M's (individual applied torques) with the exponent 2 replaced by 1. The i's are the ratios of the instantaneous angular velocities, and the η's "corrective coefficients" equal to unity in absence of friction. This is hard to believe for $k > 2$, because any intermediate cam will be in a condition of determinacy, making two point contacts with its neighbors, and one surface contact with its pivot. In fact, the only (approximate) values of η given are for cams with one point contact only (they depend on the friction coefficients and angles of pressure). The proof offered in the paper involves three cams only. On closer inspection of it, one is puzzled by mysterious disappearances of certain reaction forces and moments from Eqs. (13) and (16). This is done by setting a sum of n equal forces equal to zero, etc. This reviewer believes that the formulas given, however attractive, must be regarded as largely ornamental, although they are true in absence of friction ($\eta = 1$).

A. W. Wundheiler, USA

724. Dobrovol'skiĭ, V. V., On the mechanism of generation of a curve accompanying a given one (in Russian), *Trudi Sem. teor. Mash. Mekh.* **9**, 43, 50–54, 1951.

Let OACB be a hinged parallelogram, and OAC'B the corresponding antiparallelogram. The curves traced by C and C', when **0** is fixed, are called "associated." If the trace of C is algebraic of equation $F(x, y) = 0$, the author puts $x = a\cos\alpha + b\cos\beta$, $y = a\sin\alpha + b\sin\beta$ where OA $= a$, OB $= b$, $\angle$XOA $= \alpha$, $\angle$XOB $= \beta$. This transforms the equation into $\Sigma A_{mn} \cos(m\alpha \pm n\beta + \delta) = 0$ where m and n are integers, and $\delta = 0$ or $\pm\pi$. Author shows how to mechanize the last relation by adding to OACB: as many planetary transmissions as there are terms in the last summation; six times as many bars; and a linkage for straight-line guidance. He also explains the procedure for deriving the equation of the associated curve.

A. W. Wundheiler, USA

725. Cherkudinov, S. A., and Speranskiĭ, N. V., On the synthesis of plane link mechanisms with stops (in Russian), *Trudi Sem. teor. Mash. Mekh.* **9**, 43, 5–12, 1951.

In a previous paper by the first author ["The method of multiple interpolation in mechanism design," *Trudi Sem. teor. Mash. Mekh.* **11**, no. 40, 1950], inaccessible to this reviewer, the first three sections deal with four-bar curves tangent to a circular arc at both its end points. Graphical methods are given for the determination of such curves, given the positions of the linkage crank corresponding to the end points of the circular arc. The present paper translates the graphical method into an analytical one. A numerical example is given.

A. W. Wundheiler, USA

Gyroscopics, Governors, Servos

(See also Revs. 712, 718)

726. St. Clair, D. W., Coombs, W. F., Jr., and Owens, W. D., Frequency-response analysis for industrial automatic-control systems, *Trans. ASME* **74**, 7, 1133–1147, Oct. 1952.

See AMR **5**, Rev. 998.

727. Boksenbom, A. S., and Hood, R., Automatic control systems satisfying certain general criterions on transient behavior, *NACA Rep.* 1068, 13 pp., 1952.

See AMR **5**, Rev. 2275.

728. Scott, W. E., An introduction to the analysis of nonlinear closed cycle control systems, "Automatic and manual control," New York, Academic Press, Inc., 249–261, 1952. $10.

The principal concern of the paper is a class of control systems which differs from linear ones by nonintended physical defects of linearity. The equation $\ddot{x} + f(x)\dot{x} + g(x) = e(t)$ gives an example of such systems. Methods for tackling this equation are described; preference is given to iteration and to topological methods. These are concerned with the trajectories of an equation $dy = (Rx, y)dx$, which is closely related to the original equation. Author proposes also a concept of stability by setting up tolerance inequalities; he concludes with 14 references for nonlinear problems.

Hans Bückner, Germany

729. Minorsky, N., Non-linear control systems, "Automatic and manual control," New York, Academic Press, Inc., 309–318, 1952. $10.

Paper considers some of the benefits to be derived from the deliberate incorporation of nonlinearities in control systems. These benefits include compensation for other nonlinearities already present, production or suppression of an oscillation, frequency demultiplication, synchronization, asynchronous excitation and quenching, and parametric oscillation. A brief, competent review of generally known characteristics of nonlinear systems from the viewpoint of their useful applications.

H. K. Weiss, USA

730. Malkin, I. G., On a problem of the theory of stability of systems of automatic regulation (in Russian), *Prikl. Mat. Mekh.* **16**, 3, 365–368, May/June 1952.

The following problem was proposed by M. A. Aĭserman [*Usp. matem. Nauk* **4**, 4, 1949]. Let the system of order n

$$\dot{x}_1 = a_{1i}x_i + f(x_k) \qquad \dot{x}_s = a_{si}x_i,\ s = 2, 3, \ldots, n \qquad [1]$$

where the a_{ji} are constants representing an automatic regulator. Let the system such as [1] but with $f(x_k)$ replaced by hx_k have all characteristic roots with negative real parts for all h such that $0 < \alpha < h < \beta$. Assuming that $f(0) = 0$ and that for all $x_k \neq 0$: $\alpha x_k^2 < f(x) < \beta x_k^2$, is it true that $x = 0$ will be asymptotically stable for [1], whatever the initial disturbance? In the present paper this is shown to hold for the two systems

$$\dot{x} = ay + f(x), \qquad \dot{y} = bx + cy, \qquad [2]$$

$$\dot{x} = ax + f(y), \qquad \dot{y} = bx + cy, \qquad [3]$$

under the following assumptions: *System* [2]. Setting $f(x) = xh(x)$, then for $|x|$ sufficiently large: $ch(x) > ab$. *System* [3]. Setting $f(y) = yh(y)$, then for $|y|$ sufficiently large: $ac > bh(y)$.

The proofs are based on the use of the function V of Lyapunov. [See Erugin, AMR **4**, Revs. 2348, 2349.]

S. Lefschetz, USA

731. Gold, H., Otto, E. W., and Ransom, V. L., Dynamics of mechanical feedback-type hydraulic servomotors under inertia load, *NACA TN* 2767, 63 pp., Aug. 1952.

Paper considers a method for predicting both the transient and frequency response of hydraulic servomotors of the type where a pilot valve controls the hydraulic flows and pressures acting on the servo piston, and where the output position is mechanically fed back to modify the pilot valve position ("permanent-droop" type). Both linear and rotational forms of servomotors are considered. Subject is pertinent because of its many engineering applications, particularly in the aircraft fields. Results given permit the dynamic characteristics to be computed from design constants.

Paper particularly considers effect of inertia load; it concludes that this effect is significant during acceleration—but not during deceleration periods. Result is to alternate differential equations to describe response; the equation used depends upon whether acceleration or deceleration is taking place. Transient responses thus predicted are correlated with experimental data, and a favorable agreement is noted. Paper also treats frequency response of such servomotors. An approximate method is used, necessitated by the nonlinear action. Frequency responses thus predicted are also correlated by experimental tests, with favorable agreement.

Treatment appears valid, and approximations used are generally reasonable. Assumptions regarding an idealized type of pilot-valve characteristic may restrict the applicability of the paper for some problems. This appears to be a new treatment of an old problem, and paper is recommended to engineers working in the hydraulic control field. R. J. Kochenburger, USA

732. **Glaus, R., The automatic directional control of aircraft** (in German), *ZAMP* **3**, 4, 5; 298–308, 371–382; July, Sept. 1952.

In an introduction to the problem of automatic control of an airplane, author describes how such a control acts and how it can be designed. The good bibliography may help the interested reader to a better understanding of many details very briefly outlined in this paper. I. Flügge-Lotz, USA

733. **Leonhard, A., Relative damping as criterion for stability and as an aid in finding the roots of a Hurwitz polynomial,** "Automatic and manual control," New York, Academic Press, 25–35, 1952. $10.

Tables are listed for computing relative damping of a servo system from coefficients of characteristic equation. Formulas are given whereby tables can be extended. Application is made to locating actual roots. W. A. Mersman, USA

Vibrations, Balancing

(See also Revs. 699, 700, 707, 708, 722, 728, 1084)

734. **Hoppmann, W. H., 2nd, Forced lateral vibration of beam carrying a concentrated mass,** *J. appl. Mech.* **19**, 3, 301–307, Sept. 1952.

Equations are developed for deflection and strain in simply supported beam carrying a concentrated mass at midpoint; harmonic force is applied to concentrated mass. Good general agreement is obtained with experiments. For type of beam used in experiments, deflections can be obtained treating beam as one-degree-of-freedom system. This is not true for strains.

R. P. Felgar, Jr., USA

735. **Lee, E. H., On a "paradox" in beam vibration theory,** *Quart. appl. Math.* **10**, 3, 290–292, Oct. 1952.

The paradox concerning the source of energy for the vibration of a beam traversed by a constant force moving with a constant velocity v is discussed and shown not to exist. Difficulties in accounting for the energy are eliminated when the vertical velocity of the point of application of the force is recognized as having an additional component by virture of its velocity of motion.

W. T. Thomson, USA

736. **Junger, M. C., Vibrations of elastic shells in a fluid medium and the associated radiation of sound,** *J. appl. Mech.* **19**, 4, 439–445, Dec. 1952.

This is a study of the vibrations of thin elastic shells freely suspended in a compressible fluid medium. The effect of the fluid reaction on the dynamic characteristics and, in particular, on the natural frequencies is investigated for cylindrical and spherical shells. The dynamic configuration of such shells undergoing forced vibration and the associated radiation of sound are determined. The problem is analyzed by means of the classical methods of the theory of mechanical vibrations; the Lagrange equations for the system are derived, the fluid reaction being introduced in the form of generalized forces. From the boundary condition that the normal shell deflection be equal to the normal fluid-particle displacement at the shell surface, and introducing the concept of acoustic impedance, it is shown that the fluid reaction is equivalent to an accession to the inertia of the shell and to a damping force. Numerical examples show that the effect of the fluid reaction on the dynamic characteristics of a shell may be of such magnitude as to render valueless the calculations neglecting it.

From author's summary by G. W. Swenson, Jr., USA

737. **Zizicas, G. A., Dynamic buckling of thin elastic plates,** *Trans. ASME* **74**, 7, 1257–1266, Oct. 1952.

The transverse vibrations of rectangular plates with an initial deflection are studied (by solving the corresponding equation by separation of the variables) when external loads are applied in the plane of the plate. Constant loads in one and two directions suddenly applied are considered; also loads varying in an arbitrary way with time. Curves of maximum deflection versus ratio loads to their critical value are obtained. Small deflection theory is used. M. G. Salvadori, USA

738. **Kanai, K., and Osada, K., The result of observation concerning the waves caused in the ground by building vibration,** *Bull. Earthq. Res. Inst., Tokyo,* **29**, part 3, 511–518, Sept. 1951.

A series of vibration tests of buildings with a vibrator are carried out, together with seismometric measurements of ground oscillations at the various distances from the buildings. Authors find that the amplitude of ground motion close to the buildings is almost equal to that at the building base. They conclude that the motion at the building base is transmitted into the ground as seismic waves. This property seems to correlate with the damping resistance of buildings. Attention should be paid to this fact in order to construct a building economically.

Tsuneji Rikitake, Japan

739. **Dehalu, J. M., Damping of systems with double suspension. Its influence on comfort of vehicles** (in French), *Rev. univ. Min.* (9) **8**, 8, 303–319, Aug. 1952.

Equations of a system of two masses and two springs, subjected to periodic motion, are expressed in terms of dimensionless ratios. Optimum location and amount of viscous damping of springs are studied in detail. Results are directed to vehicle suspension, particularly railroad trucks. Article is purely theoretical.

B. S. Cain, USA

740. **Dol'berg, M. D., On the critical angular velocities of a rotating shaft** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **85**, 1, 45–48, July 1952.

Author gives a qualitative picture of distribution of angular velocities of shafts with concentrated as well as distributed masses, and supported by an arbitrary number of elastic supports. Displacement function for points on shaft axis is satisfied by an integral equation from which are deduced several important conclusions. One of these is that the usual substitution of concentrated masses for distributed masses leads to a distorted picture of the critical angular velocities. Actually, for finite number of

concentrated masses, the number of critical velocities always equals the number of masses, while for distributed masses, critical angular velocities may be entirely absent.

It is stated that researches of Biezeno and Grammel [*Technische Dynamik*, 1939] are incomplete and contain substantial errors for the uniformly distributed masses. S. Sergev, USA

741. Pöschl, Th., On principal vibrations with finite amplitudes (in German), *Ing.-Arch.* **20,** 3, 189–194, 1952.

Author considers systems of two degrees of freedom (e.g., a double pendulum) and investigates the paths of a representative point in an x-y-plane. Such paths do not give all the information about the motion of the system under consideration, the time being eliminated, but some aspects of the problem can be treated (e.g., the principal oscillations). On the other hand, elimination of time results in a reduction of the order of the problem (order of the differential equations), for the systems considered from four to two. Author suggests the use of Jacobi's principle for establishing the differential equation of the paths.

Author then goes on to treat a special system, the double pendulum, and, more specifically, its principal oscillations. He defines as a limit curve (Grenzkurve) in the x-y-plane the loci of those extreme positions from which, as starting positions, principal oscillations will occur (i.e., the paths will pass through the origin of the x-y-plane).

Next, author wishes to derive the differential equation for the limit curves. For this purpose, he establishes the slope of the paths on the limit curve and considers this expression to be the differential equation of the limit curve. Reviewer considers this last step an assertion without proof. The fact that in special cases, as, e.g., for linearized systems, the expression thus derived does constitute the differential equation of the limit curve cannot be taken as such proof. K. Klotter, USA

742. Roberson, R. E., On the relationship between the Martiensson and Duffing methods for nonlinear vibrations, *Quart. appl. Math.* **10,** 3, 270–272, Oct. 1952.

Author investigates one-term approximation methods for problems of nonlinear synthesis. It is found that results obtained by methods listed in title are not independent. Equations are developed for a single-degree-of-freedom system without dissipation but containing a nonlinear spring. One special case is discussed where the nonlinear element is a simple power function. In this case, the two methods lead to identical one-term approximations which are related by a proportionality constant.

W. J. Worley, USA

743. Cartwright, M. L., Van der Pol's equation for relaxation oscillations, Contrib. Theory Nonlinear Oscill. **2,** Annals Math. Studies no. 29, 3–18, 1952. $1.50.

Asymptotic expressions are obtained for the period and amplitude of the steady-state solution of Van der Pol's equation with large nonlinearity. The results go further than those of Ph. leCorbeiller [*J. Inst. elec. Engrs.* **79,** 361–378, 1936] but not so far as those of A. A. Dorodnitsín [AMR **1,** Rev. 769].

S. H. Crandall, USA

744. Colombo, G., On a nonlinear system with two degrees of freedom (in Italian), *R. C. Semin. Mat. Univ. Padova* **21,** part I, 64–98, 1952.

Author considers the system of differential equations of nonlinear mechanics

$$\left.\begin{aligned} \ddot{x} - \alpha\dot{x} + 3\gamma x^2\dot{x} + x + m_1 y &= 0 \\ \ddot{y} - \beta\dot{y} + 3\delta y^2\dot{y} + (1+\rho)y + m_1 x &= 0 \end{aligned}\right\} \qquad [1]$$

where α, β, γ, δ, m_1, m_2 are very small constant parameters; $\alpha, \beta, \gamma, \delta, m_1, m_2$ are positive. By first-approximation method of M. L. Cartwright, author determines the periodical solutions of [1] and studies profoundly their stability in some particular cases.

Dario Graffi, Italy

745. Schaffner, J. S., Almost sinusoidal oscillations in nonlinear systems. Part II. Synchronization, *Univ. Ill. Engng. Exp. Sta. Bull. Ser.* no. 400, 31 pp., May 1952.

746. Eisele, F., Generation sources of vibration phenomena in machine tools (in German), *ZVDI* **94,** 25, 843–848, Sept. 1952.

Author describes briefly the development of research in Germany and the cooperation between industry and technical universities. He lists the most important generation sources and means of detection and elimination. An example of practical research is worked out in detail. W. L. Esmeijer, Holland

747. Daniels, F. B., A planimetric method of harmonic analysis, *Rev. sci. Instrum.* **23,** 7, 369–370, July 1952.

Paper describes an extension of Fischer-Hinnan method of finding Fourier coefficients of an arbitrary function. Extension consists in replacing values of arbitrary function at discrete points by planimetric integrals over discrete intervals. Advantage of this process over older one is that correction for higher harmonics is considerably less. The second equation in the paper contains a misprint. K. H. Griffin, USA

748. Drobot, S., On torsional vibrations of shafts (in Russian), *Arch. Mech. stos.* **3,** 2, 127–146, 1951.

Author develops a method by which one may solve the frequency equation of a shaft in torsional vibrations with any number of masses, where all but a few are equal and equally spaced. Author shows that the roots of this equation are, in most cases, within certain rather narrow intervals, easily determined from the exact solution of a shaft with only equal masses (which is also presented). Furthermore, an iterative method is developed to determine the solution within any required accuracy. For the special case where only two masses differ from the rest, a nomogram is presented. Paper contains many misprints.

F. I. Niordson, Sweden

749. Corbetta, G., Calculation of bending vibrations of motorshafts with counterweights (in Italian), *Aerotecnica* **32,** 3, 127–134, June 1952.

Author calculates the natural bending frequency of a single-throw crankshaft in rigid bearings. An example of an aircraft engine gives 50,000 vibr/min, or about 25 times the rpm, so that this effect cannot be excited by unbalance or by reasonable harmonics of the gas torque variation. Elasticity of the bearing supports, which is probably important, is not considered.

J. P. den Hartog, USA

750. Lee, W. F. Z., and Saibel, E., Free vibrations of constrained beams, *J. appl. Mech.* **19,** 4, 471–477, Dec. 1952.

Method is developed for obtaining the frequency equation for lateral vibration of a beam constrained by rigid and/or elastic supports, concentrated and elasticity mounted masses. The maximum deflection curve is expanded in a series of orthogonal eigenfunctions which satisfy the end boundary conditions associated with simple, built-in, and free supports. The potential energy of the system is computed, using the series expression for the deflection curve and the defined properties of the various constraints. The requirements for minimum potential energy lead

to the frequency equation. Authors give results for several classical cases. No computations of mode shape are made.

Technique developed is theoretically sound and well presented; however, reviewer believes method is not well adapted to computation for many engineering cases and, in this respect, suffers in comparison with well-known methods (e.g., Holzer) that yield frequency and mode shape simultaneously.

R. B. Grant, USA

751. **Hearmon, R. F. S., The frequency of vibration of rectangular isotropic plates,** *J. appl. Mech.* **19**, 3, 402–403, Sept. 1952.

A brief review of theoretical accomplishments is presented, together with tabulated values from papers of Young, Ritz, Iguchi, and Barton.

A. I. Bellin, USA

752. **Cicala, P., Determination of modes and frequencies above the fundamental by matrix iteration,** *J. aero. Sci.* **19**, 10, 719–720, Oct. 1952.

Author presents general formulas for calculation of rth mode which reduce the influence of errors in the previously calculated lower frequency modes. A general expression is indicated for a factor by which the dynamical matrix is multiplied, thus sweeping out from the column of parameter amplitudes the first component in the modal expansion. Author's equations yield, as a particular case, the expression for the sweeping matrix discussed by Flomenhoft. [See AMR **5**, Rev. 950.]

Paul G. Jones, USA

753. **Bourcier de Carbon, C., Analytical study of shimmy of airplane wheels** [Translation from *ONERA Publ.* no. 7, 1948], *NACA TM* 1337, 126 pp., Sept. 1952.

A theoretical study is made of the shimmy phenomena encountered in the rolling of a swiveling landing gear equipped with a pneumatic tire. The analysis deals largely with the effects of tire elasticity on the shimmy phenomena and, to a lesser extent, with the effects of structural elasticity. Effects of trail, fluid, and friction damping, spring-restoring moments, and gear tilt are considered. Two approximations are presented for the equations of motion of a tire where the tire is assumed not to skid. The more advanced approximation takes into account the lateral and torsional elasticity of the tire, its cornering power, and a coefficient describing its turning ability. The basic assumption for the tire motion for this case is that the deviation of the path of motion of the ground contact area of the tire from a straight line parallel to the wheel plane is linearly dependent on the side force F and the torsional moment L acting on the tire, or, in other words, the curvature of the tire path y_{xx} is governed by the equation $y_{xx} = R\epsilon F - RL$, where $R\epsilon$ and R are the constants of proportionality in the terminology of the paper. Use of this equation for the case of a laterally rigid swiveling landing gear leads to a fourth-order linear differential equation, while the elementary theory gives a third-order equation. Theoretical predictions of the elementary and advanced theories are compared with each other and with the earlier American theoretical and experimental work of Kantrowitz and Wylie. These comparisons indicate that the proposed theory is in reasonable agreement with the experimental data and that it more adequately predicts the details of the shimmy phenomena than the earlier American theory. No mention is made of the various German theories of wheel shimmy, such as those of Schlippe and Dietrich, which were apparently not available to the author. Some of these German theories consider the shimmy problem in much greater detail than the present paper. However, in view of the reasonable agreement with experiment indicated in this paper, it may well be that the added complications of more advanced theories are unnecessary, so that the proposed theory may be satisfactory for practical use. However, this conclusion needs further experimental substantiation. Also, in order to make practical use of the present theory, there remains the problem of determining the tire characteristics required in the theory.

R. F. Smiley, USA

754. **Lambossy, P., Forced oscillations of an incompressible viscous liquid in a rigid horizontal tube. Calculation of the friction force** (in French), *Helv. phys. Acta* **25**, 4, 371–386, June 1952.

This is the first part of a theoretical study in physiology on the action of the pulse. Author calculates the laminar oscillations set up by a simple harmonic pressure difference between the ends of a long rigid straight tube of circular section. End effects are neglected, and the motion is thus qualitatively dependent only on the Reynolds number formed from the radius of the tube, the frequency of oscillation, and the kinematic viscosity. The solution involves Bessel functions of complex argument and was previously given by Richardson and Tyler [*Proc. phys. Soc. Lond.* **42**, 1–15, 1929], by Sexl [*Z. Phys.* **61**, 349–362, 1930], and with extensions by Gerbes [AMR **5**, Rev. 2657]. This work seems to be unknown to author, who is extending his work to periodic flow in elastic tubes; see Morgan [AMR **5**, Rev. 2655].

F. Ursell, England

755. **Hukuo, N., Graphical method for studying steady forced vibrations of non-linear systems,** *J. Japan Soc. appl. Mech.* **5**, 27, 4–8, 1952.

Method is an iterative procedure closely resembling that of Rauscher [*J. appl. Mech.* **5**, p. A-169, 1938] but makes use of total energy vs. displacement curve as well as displacement-time and velocity-time curves. General one-degree-of-freedom system with nonlinear restoring force and nonlinear damping force is treated. Results of calculations for case of simple pendulum with viscous damping in large amplitude forced vibrations are shown. It is stated without proof that method converges rapidly to both stable and unstable solutions.

S. H. Crandall, USA

756. **Livshits, P. S., On forced vibrations striking a stop** (in Russian), *Zh. tekh. Fiz.* **22**, 6, 921–931, June 1952.

A theoretical analysis, with experimental verification, of the periodic motion of a spring-mounted mass striking a resilient boundary at one extreme of its motion. The other end of the spring is given a simple harmonic motion. Expressions are derived for the speed of impact in terms of design parameters. They disclose the influence of boundary hardness, and show the possibility of designing impact mechanisms with "series" and "shunt" characteristics (i.e., velocity increasing with increasing boundary hardness, or velocity substantially constant with increasing boundary hardness). Experiments were run with steel mass striking steel, stone, and wood boundaries. Results for steel on steel were compared with theory and show good agreement.

Walter W. Soroka, USA

757. **Riz, P. M., Solution of the wave equation for a region near to a known region** (in Russian), *Prikl. Mat. Mekh.* **16**, 3, 345–348, May/June 1952.

Author studies the wave equation $\nabla^2 u + \lambda u = 0$ with the boundary condition $u(x, y) = 0$ in a domain $D(x, y)$ neighboring to $D_0(x, y)$, for which the solution is known. The variables x, y are replaced by $\xi = x + \epsilon f_1(x, y)$; $\eta = y + \epsilon f_2(x, y)$, so chosen that to $D(x, y)$ corresponds $D_0(\xi, \eta)$, ϵ being a small parameter. Using similar notations $x = \xi + \epsilon\psi_1$; $y = \eta + \epsilon\psi_2$, the original equation is transformed into another one in terms of ξ, η, ψ_1 and ψ_2. Expressing ψ_1 and ψ_2 as power series arranged according to

the powers of ϵ, one obtains a recurrent sequence of equations of which the first one is homogeneous and the other nonhomogeneous. The latter is considered as representing forced oscillations at resonance since $\lambda^{(0)}$ is the eigenvalue of the first equation. The necessary and sufficient condition for the existence of bounded solutions of the sequence is the orthogonality of the right-hand terms with respect to the corresponding eigenfunctions. At the end of the procedure, the variables x and y are introduced, which gives thus a series solution in D in terms of another parameter μ, related to ϵ through a power series $\mu = \lambda - \Sigma_{\nu=0}^{\infty} \epsilon^{\nu} \lambda^{(\nu)}$.

N. Minorsky, France

758. Tsídzik, P. V., Application of the small parameter method to the solution of problems of natural vibrations of nearly rectangular plates (in Russian), *Prikl. Mat. Mekh.* **16**, 3, 349–351, May/June 1952.

This paper is merely a numerical application of the small-parameter method outlined in the paper by Riz (see preceding review) when $D_0(x, y)$ has rectangular and trapezoidal forms. Author uses series solutions $u_{mn} = \Sigma_{\nu=0}^{\infty}\epsilon^{\nu}u_{mn}^{(\nu)}$ and $\lambda_{mn} = \Sigma_{\nu=0}^{\infty} \epsilon^{\nu} \lambda_{mn}^{\nu}$ which are replaced into the wave equation, and the recurrent procedure is carried out numerically for these two forms. The eigenvalues, frequency and amplitude coefficients, as well as the nodal lines are calculated for the first four overtones.

N. Minorsky, France

759. Graham, E. W., and Rodriguez, A. M., The characteristics of fuel motion which affect airplane dynamics, *J. appl. Mech.* **19**, 3, 381–388, Sept. 1952.

Problems in aircraft dynamics may be significantly affected by fuel motion. In this paper, the response of the fuel to simple harmonic motion of a rectangular tank in translation pitching and yawing is studied. The partial differential equation for the velocity potential $\nabla^2\phi = 0$ is satisfied for linearized boundary conditions at the tank boundaries. All tank accelerations are assumed small compared to gravity, and all angular displacements are assumed small. The mathematical development is abridged and the reader is referred to authors' paper reviewed in AMR **5**, Rev. 2463. Using force and moment expressions developed in the hydrodynamical analysis, simple mechanical systems equivalent to the fuel are constructed.

R. L. Bisplinghoff, USA

Wave Motion, Impact

(See also Revs. 756, 777, 875, 948, 952)

760. Szebehely, V. G., and Brooks, S. H., Preliminary experimental investigation of slamming, *David W. Taylor Mod. Basin Rep.* 812, 12 pp., July 1952.

Experimental results are presented for impact tests on the model of a ship's hull. The impact was produced by dropping the model onto the water surface of a test basin. The vertical distance of free fall before striking the water was 0.6 ft. The tests were performed both for zero forward speed and for a forward speed of three knots. The hull was 11 ft in length and, with an additional mass attached near its center, weighed about 293 lb. Accelerations were measured with a Statham accelerometer attached near midship onto a strut fastened to the bottom of the hull.

Three acceleration-time curves are shown for the experimental data, and these are compared with theoretical results based on a simplified assumption of two-dimensional fluid flow treated in a previous paper [AMR **5**, Rev. 3606] by the senior author.

Maximum deceleration measured was 4.4g, while the corresponding theoretical deceleration is 4.7g. Approximate time to reach peak acceleration is 3 millisec from experiment and about the same from theory.

Reviewer agrees with authors that more tests are necessary and that these should include a larger number of such parameters as hull shape. This further experimentation should provide more realistic tests to represent conditions actually encountered in service.

W. H. Hoppmann, II, USA

761. Fogagnolo Massaglia, Bruna, Propagation of elastic waves in a spherical layer and application to seismology (in Italian), *Ann. Mat. pura appl.* (4) **33**, 367–379, 1952.

Author identifies the velocities of Rayleigh and Love waves as the velocities of the normal modes of vibration in a meridian plane and perpendicular to it of a model of the lithosphere. This model consists of a homogeneous spherical stratum bounded internally by a sphere on which the displacement is zero. To obtain agreement with observation, author has to assume the lithosphere is 4500 km thick, with uniform properties over this distance. This is hardly consistent with present views on the subject [e.g., Bullen, "Introduction to seismology," 1947, chap. 13].

J. M. Jackson, Scotland

762. Schirmer, H., On bending waves in rods (in German), *Ing.-Arch.* **20**, 4, 247–257, 1952.

Author considers the propagation of flexural waves in bars due to shock. First, the elementary transverse and torsional waves are analyzed separately, with the effect of the shearing force and with the rotatory inertia included. Then, the velocities and frequencies of the flexural sine wave are discussed. The propagation of the flexural shock acting at the origin of an infinitely long bar with a hinged support at the origin is examined, and the form of the wave front at high frequencies is determined. Diagrams of bending moments for various wave forms illustrate the procedure outlined.

Wilhelm Ornstein, USA

763. Homma, S., Initial value problem in the theory of elastic waves, *Geophys. Mag.* **23**, 2, 145–182, Jan. 1952.

Article is a contribution to the theory of elastic waves generated from the surface of a spherical cavity in an infinite medium. Analysis is given of the solution of the displacement equations of motion governing the small disturbances set up in an isotropic, homogeneous, elastic medium, under zero body force, due to prescribed initial distributions of displacement and velocity. Separable solutions of these equations are expressed in terms of quantities of the form $A_{mn}R_{n+1/2}(r)\Theta_n^m(\Theta)\Phi_m(\varphi)T(t)$; m and n are integers with $|n| \geq m$; r, Θ, and φ are spherical polar coordinates, and t is the time; R involves general cylinder functions, Θ involves associated Legendre functions of the first kind, Φ is either $\cos m\varphi$ or $\sin m\varphi$, and T is $\exp(ipt)$. Such solutions are of three types; the first involves only dilatation, the second and third involve only rotation, and the third has zero radial component of rotation. The first and third types have the same variation in φ. A problem of the first kind is defined as follows: A solution that is a linear combination of the first and third types, the same wave length being chosen for each type, is generalized through integration over an infinite wave-length range, and now the cylinder function is taken as the Bessel function of the first kind. Special forms are then taken for the initial displacements and velocities, and the problem is solved through the use of Hankel transforms. A problem of the second kind is similarly defined, being based upon the second type of separable solution. The results found are simplified, and there is special attention to cases involving only low-order Bessel functions. Examination of solutions for the problem of the second kind shows that, if the initial displacement is confined to the interior of a sphere of radius a,

then, at a point distance $r > a$ from the center of this sphere, the S-waves arrive after a time $(r - a)/v_s$ (where v_s is the velocity of shake waves), the disturbance continues for a time $2a/v_s$ with amplitude of order $1/r$, and the waves then pass on. In the corresponding problem of the first kind, it is shown that, at a point distance $r \gg a$ from the center of the sphere, P-waves arrive after a time $(r - a)/v_p$ (where v_p is the velocity of push waves) and terminate at a time $(r + a)/v_p$, and S-waves arrive after a time $(r - a)/v_s$ and terminate P at a time $(r + a)/v_s$. If $(r - a)/v_s > (r + a)/v_p$, there is an almost quiescent régime between the arrival times of the P- and S-waves.

In reviewer's opinion, the general results of the paper are in accord with well-established results, and the merit of the paper therefore lies in the detailed examination of particular problems. The fact that many of the final formulas are in very simple forms suggests that there may be a simpler analysis establishing these results more directly. H. G. Hopkins, USA

764. **Satô, Y., Distribution of surface stress generating no Rayleigh-waves,** *Bull. Earthq. Res. Inst., Tokyo* **29**, 3, 445–453, Sept. 1951.

Author continues the investigation of vibrational sources in a semi-infinite elastic body which generate no Rayleigh waves. In an earlier paper [AMR **5**, Rev. 2565], he considered dilatational sources, whereas in the present paper the source is assumed to be a given stress distribution on the plane surface. Starting with Lamb's formulas of this problem [H. Lamb, *Phil. Trans. (A)* 203, 1, 1904], author derives a sufficient condition for stress distributions generating no Rayleigh waves, and gives numerical examples for both a sinusoidal time function and a single impulse.

Reviewer agrees with author that these results should prove of practical interest. This applies not only, as author suggests, for seismic prospecting, but also for the development of explosive charges which can be used closer to buildings without damage than the ordinary charges, if the Rayleigh wave, which constitutes the main component of the surface displacement, is not excited. Hans L. Oestreicher, USA

Elasticity Theory

(See also Revs. 784, 785, 789, 804, 874)

765. **Tiffen, R., Uniqueness theorems of two-dimensional elasticity theory,** *Quart. J. Mech. appl. Math.* **5**, part 2, 237–252, June 1952.

Paper deals with uniqueness questions arising in connection with generalized plane stress or plane strain solutions to the first and second boundary-value problem of elasticity theory. Uniqueness theorems for two-dimensional problems have been established by N. Muskhelishvili, who considered regions bounded by $n + 1$ closed contours C_i, where C_{n+1} encloses $C_1, C_2, \ldots C_n$, and who also treated the limiting case in which the region extends to infinity in all directions (references are given in the paper).

Present paper adds significantly to the apparently available literature in dealing also with the important possibility that C_{n+1} is partly at infinity and partly in the finite plane, as exemplified by the half-plane or the infinite strip. It is shown that, in this instance, uniqueness in the sense of Kirchhoff's theorem, in general, requires and is assured by the specification of the tractions at infinity of all orders higher than $o(r^{-1})$, where r is the distance from the origin. Hence, it is not permissible to prescribe arbitrarily those tractions at infinity which are of order $o(r^{-1})$. At any rate, the mere specification of vanishing stresses at infinity is insufficient to assure a unique solution. As a striking illustration of this fact, one might cite Neuber's solution for the hyperbolic notch ["Kerbspannungslehre," J. W. Edwards, Ann Arbor, Mich., 1944] in which a regular nonvanishing stress field is found to conform to surface tractions which vanish throughout the entire boundary. An analogous theorem is proved for the case of prescribed surface displacements.

All of the proofs given rest on the approach to the plane problem in terms of two complex potentials, in the particular formulation due to A. C. Stevenson. The consistent use of complex variables yields a considerable gain in simplicity.

In reconsidering the second boundary-value problem for a finite domain, author admits singularities in the surface loading as well as interior singularities, including dislocations, and then establishes uniqueness on the assumption that the difference solution introduced in the proof is free from singularities. This generalization of the usual hypotheses seems to reviewer to be less important; the more pertinent questions here would appear to be aimed at the unique specification of the various physically significant singularities themselves.

Finally, it may be worth recalling that analogous extensions to infinite domain of Kirchhoff's uniqueness theorems for three-dimensional problems are apparently still lacking. E. Sternberg, USA

766. **Stephens, Kathleen M., A boundary problem in orthotropic generalized plane stress,** *Quart. J. Mech. appl. Math.* **5**, part 2, 206–220, June 1952.

Expressions for stresses in an aeolotropic plate containing a curvilinear triangular hole are developed for various boundary stress conditions on plate and hole.

Method is an extension of that of Livens and Morris and involves conformal transformation to determine stress functions. Approximations made in the evaluation of certain integrals give results that are valid only on the boundary of the hole and for a finite region around it. This does not seem to seriously limit the usefulness of results.

Evaluations are made and values of tangential stress concentrations given for several positions on hole boundary for plates of spruce and oak for the following load conditions: (1) Plate in uniaxial tension; (2) plate in uniform tension in all directions; (3) uniform pressure on hole boundary. M. V. Barton, USA

767. **Grioli, G., Properties of averages and the elastic equilibrium** (in Italian), *Cons. naz. Ricer.* no. 337, 10 pp., 1952 = *Ann. Mat. pura appl.* (4) **33**, 1952.

M. Picone has developed a general approach for the integration of linear partial differential equations and applied it to the equations of elasticity formulated in terms of the displacements. Author applies the method directly to the case of the equations of elasticity expressed in terms of the stress components and for both isotropic and anisotropic bodies. The so-called astatic and hyperstatic coordinates, first introduced by A. Signorini, are generalized, and, by a combination with the equations of equilibrium, certain inequalities are derived which give a lower bound for the maximum absolute value of the stress components within the elastic body. Lower bounds of the same quantities are also derived by using a system of functions orthogonal within the domain of the elastic body. The same approach is used for obtaining lower bounds for the maximum absolute value of the displacements. A complete system of functions orthogonal within the domain covered by the elastic body is used for approximate integration of the equations of elasticity. Linear combinations of these functions with undetermined coefficients are assumed for the components of stress, and the values of these coefficients are obtained from the equations resulting by minimizing the expression for the potential energy of the system. It is suggested that

such a set of orthogonal functions be constructed by means of suitable linear combinations of monomials 1, x_1, x_2, x_3, x_1x_2, x_2x_3, x_3x_1, etc., formed by the coordinates x_1, x_2, x_3 of an arbitrary point. Its completeness is assured by a theorem recently proved by L. Amerio [*Amer. J. Math.* **49**, 447–489, 1947]. The possibility of application to specific cases is indicated, but no examples are worked out. A specific application for the case of elastic displacements was given by the author elsewhere [AMR **5**, Rev. 1690]. George A. Zizicas, USA

768. Grioli, G., Quantitative relations for the stress state of any continuous system and for the deformation of an elastic body in equilibrium (in Italian), *Cons. naz. Ricer., Pubbl. Ist. Appl. Calc.* no. 335 = *Ann. Mat. pura appl.* (4) **33**, 239–246, 1952.

Generalizing certain notions introduced by A. Signorini [*Ann. Scuola norm., Pisa* (II) **2**, 231, 1933], author deduces inequalities for components of the stress tensor at equilibrium in loaded body of whatever physical nature. In case of homogeneous anisotropic materials, results are extended to components of strain tensor and displacement vector. F. K. G. Odqvist, Sweden

769. Arf, C., On the determination of multiply connected domains of an elastic plane body, bounded by free boundaries with constant tangential stresses, *Amer. J. Math.* **74**, 4, 797–820, Oct. 1952.

See AMR **3**, Rev. 844.

770. Hilton, H. H., Thermal stresses in bodies exhibiting temperature-dependent elastic properties, *J. appl. Mech.* **19**, 3, 350–354, Sept. 1952.

Differential equations are established for thermal stresses in thick-walled cylinders and thin circular disks made of incompressible materials with temperature-dependent shear modulus G and coefficient of thermal expansion α. General solution is given for the cylinder. Stresses are calculated for two particular examples; graphs are given to show variation of G and α against temperature for the material assumed. These stresses are lower than corresponding values for temperature-independent properties [e.g., Timoshenko and Goodier, "Theory of elasticity," eq. 247]. Reviewer feels that the value of the comparison is reduced by the high temperature gradients in the examples, giving stresses considerably exceeding the proportional limit of steel used; for lower gradients, the effect of variable G and α is diminished. G. Sved, Australia

771. Horvay, G., The plane stress problem of perforated plates, *J. appl. Mech.* **19**, 3, 355–360, Sept. 1952.

See AMR **5**, Rev. 1655.

772. Danilovskaya, V. I., On a dynamical problem of thermoelasticity (in Russian), *Prikl. Mat. Mekh.* **16**, 3, 341–344, May/June 1952.

Author studies the one-dimensional dynamical problem of a semi-infinite body which is heated at the boundary plane by convection. The corresponding mathematical problem consists of a second-order linear inhomogeneous partial differential equation with simple linear boundary conditions. The problem is solved for the unknown stress by an operational method which yields the solution in elementary functions. It is shown that the stress-time function at a given point consists of an analytical part and an additional part which is zero until an elastic wave reaches the point from the boundary, starting out at the instant of heating. This result is given in dimensionless form, and it is shown how the stress-time curve changes its features with a change of the material thermic and elastic parameters. In all cases, after passing a minimum and a maximum, stresses decrease rapidly toward zero. F. Niordson, Sweden

773. Reiner, M., The theory of cross-elasticity (in Hebrew with English summary), *Hebr. Inst. Technol., Haifa, Sci. Publ.* 4, 15–30, 1951.

Author analyzes mathematically the physical evidence of Poynting, that severe axial torsion of metal rod increases length and decreases diameter; of Rivlin, that torsion of rubber cylinder requires axial pressure to maintain length; and of Weissenberg, that elastic fluid climbs rod rotated in it. Since width change of strip under simple infinitesimal shear is zero, author concludes "cross-elasticity . . . is a second-order phenomenon." He proposes finite-strain Hooke's law with stress tensor **P**, strain tensor **E**, unit tensor **I** (reviewer's notation) by $\mathbf{P} = F_0\mathbf{I} + F_1\mathbf{E} + F_2\mathbf{E}\cdot\mathbf{E}$ with "coefficient of cross-elasticity" F_2 allowing for "second-order" effects. Author proposes, generally, that F's should be functions of strain stated in the three invariants of **E**. Author's fundamental attitude to problem is: "The two concepts of stress and strain are not of equal standing. While 'stress' is an unequivocal physical quantity being derived from the definite quantities 'force,' 'area,' and 'orientation in space,' this is not so with respect to 'strain.' "

Hoping to check increasing volume of unnecessarily complicated theory on finite strain, reviewer indicates simpler approach is possible to finite simple shear, for example. Reviewer's fundamental attitude is: "The two concepts of 'stress' and (elastic) 'strain' *are* of *equal standing*. (Elastic) 'strain' is an unequivocal physical quantity derived from the definite quantities 'relative-displacement,' 'length,' and 'orientation in strain-space' (deformed body)." Stress and elastic strain tensors both "transfer" by "rotation" relative to substance. In isotropic substance presumably treated by author, **P** and **E** are always coaxial by "transfer" in simple shear. (This "transfer" is usually referred to misleadingly as "rigid rotation" to pass from pure to simple shear.) Using author's Hooke's law *without* F_2 and with F's constant is simplest physical behavior of substance. With transfer mechanism, this gives required cross-elasticity effects. Stated otherwise, cross elasticity is the "stretch" of lines elements and not the "strain" that is a component of a tensor. (Reviewer, May 1950, unpublished.) Author's stress-strain form *with* F_2 may be convenient when *physical* behavior of substance is not linear. Reviewer feels there is general confusion between the two distinct aspects, (a) physical behavior of substance, (b) particular boundary problem. [See e.g., C. Truesdell, "The mechanical foundations of elasticity and fluid dynamics," *J. rational Mech. Anal.* **1**, 1, 1952]. K. H. Swainger, England

774. Reiner, M., Cross-elasticity, *Bull. Res. Counc. Israel* 1, 1/2, p. 126, Mar. 1951.

Further notice of publication of preceding review. Author notes that the distribution of axial pressure in Rivlin's test of axial torsion on a rubber cylinder is "not, however, in accordance with what is required by the Poynting effect." Reviewer does not understand the meaning of this statement considered in relation to Poynting's publication. K. H. Swainger, England

775. Weber, C., Sphere with normal concentrated forces (in German), *ZAMM* **32**, 6, 186–195, June 1952.

Axially symmetrical loading on a sphere defines two potential functions throughout the sphere, whose boundary values represent the loading. Author expands these potentials in series of homogeneous zonal harmonics, and by ingenious manipulation deduces series for four other harmonic functions ψ and $\phi_i (i = 1, 2, 3)$, which give the displacement u_i as $u_i = \phi_i + r^2\partial\psi/\partial x_i$. In

the application to concentrated forces, an elementary potential for the semi-infinite solid is made to provide the required potential for the sphere by inversion, and an explicit series solution given for two forces. The stress components at the center are evaluated. The singularity at the "poles" is identified with that of the Boussinesq formulas for the semi-infinite solid. Sternberg and Rosenthal [see AMR **6**, Rev. 384] have found that this is not correct, and the author's stress values differ from theirs, presumably on this account. J. N. Goodier, USA

776. **Fujita, S., Calculation of an internal stress accompanying the phase change of solids,** *J. sci. Res. Inst., Tokyo* **46,** 53–58, June 1952.

Stresses are calculated for volume changes of spherical grains in solid, using different elastic moduli for the two phases. Formulas are simplified for the case of equal moduli in both phases.

W. T. Koiter, Holland

777. **Maue, A.-W., The edge condition in the theory of diffraction of elastic waves** (in German), *Z. Naturforsch.* **7a,** 6, 387–389, June 1952.

Author discusses diffraction of elastic waves at a plane surface of rupture in the interior of an elastic solid. By considering a neighborhood of the edge, small compared with the wave length, author is justified in replacing the wave by the potential equation. Edge conditions are thus found for stresses, strains, displacements, and energy density. W. Freiberger, England

Experimental Stress Analysis

(See also Rev. 1090)

778. **Aubaud, J., Investigation of the stress-birefringence relation in Plexiglas M 222** (in French), *Rech. aéro.* no. 26, 31–40, Mar./Apr. 1952.

Author studies the change in the optical birefringence of plexiglas as a function of stress and time. Specimens used were subjected to pure compression, pure tension, and pure bending, the load being kept constant as a function of time. Author compares the results obtained from the three kinds of specimens, and indicates several conclusions. Among the most important conclusions the following should be emphasized: (1) Birefringence is directly proportional to strain, not stress; (2) Brewster's photoelastic coefficient is very nearly constant up to the second fringe in 1-cm thick specimen.

The loading frame applies the load by means of a screw. Since all the determinations were made under constant load, reviewer asks why a beam and weights were not used to apply the load.

A. J. Durelli, USA

779. **Bristow, J. R., and Ellames, F. G., Unbonded wire resistance strain gauge accelerometers,** *J. sci. Instrum.* **29,** 9, 288–289, Sept. 1952.

Accelerometers of the damped inertia type are described, in which the main elastic restraint of the moving mass is provided by unbonded free wire-resistance strain gages; change of resistance of these gages is then a measure of the accelerations experienced by the instrument. The accelerometer output is recorded with the normal type of dynamic strain-recording equipment used with bonded wire-resistance strain gages. Two accelerometers are described, having natural frequencies of 165 cps and 315 cps with outputs of 0.30 mV/V/g and 0.081 mV/V/g up to ± 3g and ± 13g, respectively; both are fluid damped to 0.6–0.7 damping ratio. From authors' summary

780. **Huggenberger, A. U., Significance of the Wheatstone bridge circuit as a measuring device in the application of bonded wire-resistance gages** (in German), *Schweiz. Arch.* **18,** 4, 105–116, Apr. 1952.

Paper is a systematic review of the various Wheatstone bridge circuits applicable in bonded wire-gage technology. Both current and voltage sensitive circuits are discussed. Their temperature-compensating properties along with special adaptabilities to specific stress conditions are shown. A pictorial tabulation of the applications, the circuit diagrams, their basic equations, and special properties is an excellent guide in the work of bridge-circuit selection. D. Vasarhelyi, USA

781. **Kuhn, R., Determination of stresses in elastic plates by means of photoelasticity** (in German), *Forsch. Geb. Ing.-Wes.* (*B*) **18,** 3, 72–80, 1952.

This is the second part of a thesis which was made in the laboratory of photoelasticity of Professor Föppl in Munich. In the first part, author describes the method used to get the moments in a bent plate. It consists in the application of the frozen technique. The plate with the frozen stresses is cut at the neutral plane, and one of the two parts is put between two polaroids, where the directions of the principal moments are determined. Afterward, the double refraction by the order of the isochromates is measured by cutting another plate along the principal moment trajectories in calibration pieces. Author then describes two applications treated by this method: (1) The case of a square plate under the action of four equal forces applied on the corners perpendicular to the neutral plane, two and two in opposite directions; (2) the case of a square plate under the action of a concentrated force in the center and with simply supported edges.

Henry Favre, Switzerland

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 698, 709, 734, 740, 813, 815, 829, 830, 850, 884)

782. **Iwiński, T., Nowiński, J., and Turski, St., Application of Ritz's method to the calculation of deflections of beams** (in Polish), *Inż. Budown.* **9,** 4, 5: 143–147, 178–179; Apr., May 1952.

After elementary explanation of procedure using polynomials instead of trigonometric series, authors apply method to calculate deflection of single and multispan beams, freely supported or with fixed ends with varying type of loading (concentrated, uniformly or linearly distributed, triangular, etc.). Several cases are calculated in all the details. The difference in deflection between that so calculated and exact deflection is 2 to 5%. The mathematics used does not go beyond elementary differential calculus.

M. Z. Krzywoblocki, USA

783. **Pao, Y.-H., and Marin, J., Deflection and stresses in beams subjected to bending and creep,** *J. appl. Mech.* **19,** 4, 478–484, Dec. 1952.

A method is proposed for determining stresses and deflections in beam bending due to creep. Authors suggest method is valid not only for the steady-state portion of the deflection history, but also for the initial stage.

Although the experimental evidence on Plexiglas cited in this paper appears to confirm the theory proposed, a few points should be raised which might indicate that its general use for other materials might not prove satisfactory: (a) In order to obtain a simple solution, the time-hardening law of creep has been assumed. Work by Phillips and Smith, Davenport, and Roberts

has indicated that the strain-hardening law, rather than the time-hardening law, is correct. (b) The change with time of the elastic strains is neglected. The initial stress distribution is linear, and changes with time to a nonlinear stress distribution. The accompanying elastic-strain changes (which incidentally would yield a nonlinear strain distribution if no further elastic adjustments were made) are neglected. A. D. Schwope, USA

784. Nuttall, H., Torsion of uniform rods with particular reference to rods of triangular cross section, *J. appl. Mech.* **19**, 4, 554–557, Dec. 1952.

Solution of the Saint Venant torsion problem is approached by determining stress function in terms of eigenfunctions having zero value at boundary. Exact solutions are found for well-known case of equilateral triangle and for right-angled isosceles triangle. Rayleigh-Ritz approximations are then obtained for isosceles triangles having height to base ratios from 0.3 to 1.5. By analogy, these tabulated solutions are applied to flow of incompressible viscous fluids in triangular tubes. C. M. Tyler, Jr., USA

785. Ling, C.-B., Torsion of a circular cylinder having a spherical cavity, *Quart. appl. Math.* **10**, 2, 149–156, July 1952.

Author presents an exact mathematical solution of the problem and gives numerical results, which are obtained by successive approximations and are related to the effect of ratio γ of cavity and cylinder radii on total twist and on shear-stress distribution across the minimum section. Two plots show, respectively, the afore-mentioned stress distribution and the stress concentration factor K, which is defined as the ratio of the maximum shear stress to the constant shear stress across the same section giving the same couple, as a function of γ. M. Kuipers, Holland

786. Onat, T., Torsion of a prismatic bar made of annealed metal (in Turkish), *Istanbul tekn. Üniv.*, 48 pp., 1951.

Author gives an approximate solution of the equation of plastic torsion of bars based on deformation theory, namely: (1) $\Delta\psi+2G\theta=F\ (\psi_x, \psi_y, \psi_{xx}, \psi_{yy})$, subject to boundary condition that $dx/dy = -\psi_y/\psi_x$. Here $\Delta\psi$ is the Laplacian of the unknown stress function $\psi(x, y)$, and G and θ are constants. By writing (1) as (2) $\Delta\psi_n + 2G\theta = F_{n-1}$, the problem is reduced to Poisson's equation. Here $F_0 = 0$ represents the elastic torsion problem of Saint Venant. F_{n-1} is obtained by using ψ_{n-1} in the known expression of F. Two iterations with the use of the relaxation method to solve the difference equations corresponding to (2) for a bar of rectangular cross section gives satisfactory results.

The problem of convergence and the bounds of solutions need further investigations. Nevertheless, author is successful in giving a method for this difficult problem and in obtaining results which are useful to engineers. A. C. Eringen, USA

787. Brøndum-Nielsen, T., Curved edge beams, *Bygnstat. Medd.* **23**, 1, 18 pp., 1952.

Paper treats curved edge beams loaded by forces perpendicular to plane of curved axis. Torsion in beam is assumed resisted by adjacent structure. Formulas are derived for various types of ring-shaped plates with curved edge beams. Ai-ting Yu, USA

788. Conklin, R. M., and Forry, D. R., Design of flat-wound tension springs, *Trans. ASME* **74**, 5, 743–749, July 1952.

Flat-wound spring is made from wire having alternate straight sections and 180° bends. Bends are alternately left and right; complete spring lies in one plane and resembles several S members joined end-to-end. Spring may be used in tension, or in compression if constrained to prevent buckling.

Principal analytical results are expressions for deflection per coil and maximum stress. Results are expressed conveniently as a nomogram, giving deflection and maximum stress as functions of spring dimensions and applied load. Round and square wire are included in the nomogram. Charles E. Crede, USA

789. Kern, J., The strength of hollow bodies loaded thermally and by pressure with special consideration of high pressure lamps (in German), *Z. angew. Phys.* **3**, 9, 321–329, Sept. 1951.

Mercury vapor lamps dissipate some energy as heat; further, their luminous density increases with vapor pressure. Strength of lamp walls thus becomes a design consideration.

Author obtains exact solutions by classical methods for thermal stresses in (1) a thick-walled hollow cylinder out of which a known amount of heat per unit length is being dissipated by conduction; (2) a thick-walled hollow sphere under similar conditions. It is assumed only that the material is elastic and has coefficients of thermal conductivity and expansion. Results for spherical body check Hopkinson [*Messenger of mathematics* 8, 168, 1879]. Thermal stresses are combined with well-known solutions for elastic stresses due to internal pressure in hollow spheres and in cylinders with closed ends, to determine stress distribution applicable to high-pressure lamps. Mathematical solutions for the cylinder are compared with the results of a photoelastic model study and observations of actual lamps. Using the maximum shearing-stress theory of strength, optimum design conditions are investigated with the aid of numerous graphs. The importance of notches and surface irregularities is not overlooked.

Reviewer finds this a most interesting paper. The validity of the maximum shear theory of strength for a brittle material like quartz glass, however, is questionable. Mohr's theory (which itself is, at best, inexact) would have been preferable.

There is evidently a typographical error in the next to last equation on p. 325. A. D. Topping, USA

790. Kreisel, H., Recent domestic and foreign testing and measuring instruments for gears (in German), *Maschinenb.-Tech.* **1**, 1, 2; 4–12, 53–60; Apr., May 1952.

Paper is entirely descriptive, without original mathematical development. Simple trigonometrical formulas give the theoretical background. Thirty very good photos and ten clear drawings explain fourteen exhaustive pages.

Instruments described constitute highly elaborate devices of the caliper type, with modern improvements which insure precision readings.

Results achieved refer both to technical accuracy and time saving. Author describes instruments, from the portable instrument for tooth calibration, table apparatus for geometrical checking of profiles, to the giant device to rectify huge gears.

Jorge E. Carrizo Rueda, Argentina

791. Heumann, H., Investigation of the change of the rolling pressure in gears with involute teeth as dependent on profile displacement (in German), *Maschinenb.-Tech.* **1**, 1, 21–26, Apr. 1952.

Paper deals with numerical computation of contact load-stress factor for 15° and 20° involute gear teeth, with account of tooth correction. S. Sjöström, Sweden

792. Merritt, H. E., Gear-tooth stresses and rating formulae, *Instn. mech. Engrs.* **166**, 2, 196–205, Proc. (A) 1952.

British standard gears are generated from a standardized basic rack and have standard diameters for given numbers of teeth and given ratio, i.e., addendum is a function of ratio as in Gleason

bevel system. With standard proportions, "strength factor," analogous to Lewis form factor, can be tabulated or charted. Similarly, "zone factor," proportional to relative radius of curvature at chosen load point, is also charted. Existing British standards also employ "speed factor" based on rpm, *not* pitch-line velocity, and derate larger gears for Hertzian load capacity by making rating proportional to 0.8 power of relative radius of curvature.

Author discusses basis for selection of chosen load points and gives strength and zone factors recalculated for commercial and precision gears—spur and helical. Further examination of Hertzian load capacity and speed factor leads to conclusion that without amendment to existing British standard ratings these can be made to agree with more rational basis by eliminating index of 0.8 to relative curvature and using pitch-line velocity as basis for speed factor. Paper concludes with some notes on vexed question of intermittent and variable loads.

Paper leads to worthwhile re-examination of British standard rating methods and should lead to improvements in them. It is supplemented by valuable discussion of equal length to paper.

Ewen M'Ewen, England

Plates, Disks, Shells, Membranes

(See also Revs. 697, 766, 770, 771, 781, 789, 811, 857, 886, 903, 1142)

793. **Kalandiya, A. I., On a mixed problem of bending of an elastic plate** (in Russian), *Prikl. Mat. Mekh.* **16**, 3, 271–282, May/June 1952.

Paper considers the problem of bending of a plate when a part of its edge is simply supported and the other part is built-in. Applying the integral expression of D. J. Sherman, author derives the integral equations of Fredholm for the problem, and analyzes the solution obtained.

From author's summary by Witold Wierzbicki, Poland

794. **Smith, R. C. T., The bending of a semi-infinite strip,** *Austral. J. sci. Res.* (*A*) **5**, 2, 227–237, June 1952.

Author treats a semi-infinite strip of width 2 extending from $y = 0$ to $y = \infty$. Strip is assumed clamped along long edges $t = \pm 1$, where t is coordinate perpendicular to length of strip. At edge $y = 0$, author assumes $\partial^2 w/\partial y^2 = f(t)$, $\partial^2 w/\partial t^2 = g(t)$, where $f(t)$ and $g(t)$ are arbitrary functions, and $w(y, t)$ is deflection. Solution for w is obtained in series form, using characteristic functions of a matrix differential equation. Paper is highly mathematical and of a rather abstract nature, no examples for specific boundary conditions at $y = 0$ being worked out.

A. M. Wahl, USA

795. **Szmodits, K., Simplified calculation of a cylindrical arch shell** (in Russian), *Acta Techn. Hung., Budapest* **2**, 2/4, 449–460, 1952.

Rigorous flexural theory of cylindrical arch shells assumes the material composing the shell is isotropic. Application of this theory of reinforced-concrete shells contradicts the usual assumption that, in members subjected to bending, concrete does not resist tensile stresses. Using latter assumption, author develops a new theory based on elementary theory of deformation, which is justifiable owing to the wide latitude in determining the modulus of elasticity of concrete. He considers this a more realistic approach. Calculations by different theories show bending moments about generatrix, which determine the loading, differ from each other by negligible amounts, and depend only slightly on the indefinite value of the modulus of elasticity of concrete. This fact confirms applicability of the different theories, and practical considerations favor the simplest theory. Author cites good agreement between his theory and observation of deformations made on many constructed structures.

S. Sergev, USA

796. **Naghdi, P. M., Bending of elastoplastic circular plates with large deflection,** *J. appl. Mech.* **19**, 3, 293–300, Sept. 1952.

A theory is formulated for the case of elastoplastic bending of thin circular plates with polar symmetrical loading. The equations are put in finite difference and summation form, and a numerical scheme for solving is described. The special case of a simply supported circular plate with a central concentrated load is considered. Using an experimentally determined stress-strain curve for 24S-T aluminum alloy, numerical solutions are obtained for two cases. In one case, the plate experiences large elastic deformations, and in the second case, large elastoplastic deformations. Theoretical and experimental results are compared for several 24S-T plate specimens. The agreement is very good.

R. L. Bisplinghoff, USA

797. **Lee, T.-C., On the stresses in a rotating disk of variable thickness,** *J. appl. Mech.* **19**, 3, 263–266, Sept. 1952.

At the very beginning, paper invites comments on relationship between special and general solutions of the problem of rotating disks, a question which may prove of practical interest to many design engineers. Judging from the point of view of disk design proper, the engineer is interested primarily in an appropriate *special* solution, giving him immediately all data necessary in determination of disk profile and stress distribution. The disk problem has, however, another important aspect, namely, its mathematical analogy to the problem of a plate of axisymmetrically varying thickness under concentrically distributed load [see L. Föppl's paper, *ZAMM* 2, 92–96, 1922], and this is one of the reasons justifying interest in *general* solutions of the problem of rotating disks. At this point, a word of warning must be directed at interested readers: While the complemetary integrals (those affected by arbitrary constants) can be easily transferred from the disk to the plate problem, the particular integral regularly causes calculational trouble in the attempt of arriving at a complete solution for the plate. A considerable number of more or less satisfactory solutions is known for the disk, but not for the plate. This is a weighty reason for the study of general solutions of the disk problem; there is always a chance of striking among them at a solution with a bridge to the plate problem [cf., in this connection, the paper by H. D. Conway, title source, **18**, 2, 140–142, June 1951, based on a paper by R. Gran Olsson on rotating disks; see reference following below]. Turning now more directly to the paper under review, we have to state that, while its author's search for generalized solutions of the disk problem is to be commended at least for the reasons just outlined, he is unfortunately insufficiently acquainted with the literature of the subject. The solution given by him (generalized exponential profile with stress expressions in terms of confluent hypergeometric series) has already been published in 1937 by R. Gran Olsson in *Ing.-Arch.*, pp. 270 and 373. The second of these two publications contains also abundant numerical tables. In the best case, Mr. Lee's tables may represent a more or less valuable addition to those given in the source just indicated.

I. Malkin, USA

798. **Wu, M. H. L., A simple method of determining plastic stresses and strains in rotating disks with nonuniform metal properties,** *J. appl. Mech.* **19**, 4, 489–495, Dec. 1952.

Paper is a continuation of author's previous work [AMR **4**, Rev. 2027] and an application to the problem stated in the title.

It contains a chart giving the rotating speed parameter in terms of maximum octahedral shear strain of the disk and a parameter determined directly from the stress-strain curve along the radius of the disk. Good agreement is obtained between the rotating speed and maximum strain determined from the chart and experimental data. P. M. Naghdi, USA

799. Yu, Y.-Y., Heavy disk supported by concentrated forces, *Quart. appl. Math.* **10,** 3, 280–284, Oct. 1952.

Muskhelishvili's solution of a two-dimensional disk with a number of concentrated forces acting in the plane of the disk has been extended to include body forces. Stress and displacement components in curvilinear coordinates are derived by use of complex variables. Specific equations are given for the case of the circular disk with boundary loads and gravitational forces. These equations are shown to reduce to the solution of Michell for the disk resting on a plane, and to the solution of Horvay and Poritsky for the disk supported at the ends of its horizontal diameter. M. V. Barton, USA

800. Szelagowski, Fr., Action of a concentrated load on an infinite plate by means of a rigid bar of circular cross section (in Polish), *Arch. Mech. stos.* **3,** 2, 99–105, 1951.

Author theoretically solves following problem: Solid bar of circular cross section is perfectly attached perpendicularly to an infinite plate so that both bodies form a unit. Concentrated force acts on bar perpendicular to its axis. Purpose is to define stresses in plate under action of force. Author does not derive fundamental equations; he "assumes" them. Problem is solved by means of complex variables and Laurent series in which only first terms with negative power coefficients are retained. Particular case is obtained when circle reduces to point, i.e., direct action of force on a point of infinite plate. Final conclusion is that action of concentrated force on infinite plate by means of solid bar of circular cross section decreases value of normal stresses and increases value of shearing stresses, in comparison to stresses which occur in case of direct action of concentrated force in a point of infinite plate. No numerical example is worked out.
M. Z. Krzywoblocki, USA

801. Gross, N., Lane, P. H. R., and Wells, A. A., Stresses in drum-heads for cylindrical vessels, *Engineering* **174,** 4511, 40–41, July 1952.

Authors present a comparison of empirical and theoretical curves with various experimental results for stresses in the heel of pressure-vessel drumheads. Stress concentration factors K_1, defined by the ratio of the maximum meridional stress in drumhead to the hoop stress in an equivalent cylinder, are plotted against the ratio of the depth of the drumheads (h_0) to the diameter of the equivalent cylinder (D_0).

Included in the comparison are: (1) Empirical curve given by British standard specification 1500: 1949; (2) curve for ellipsoidal drumheads, derived by Coates' analysis [*Trans. ASME* **52,** 1930]; (3) curve for torispherical drumheads by the mechanical analog developed by Wells [AMR **4,** 4358]; (4) experimental points by various investigators in England, France, and United States.

Authors indicate that the experimental points are, with one exception, above the British Standards Institution's curve.
T. H. H. Pian, USA

802. Persen, L. N., Influence fields for circular and infinite cantilever plates, *Tekn. Ukeblad, Oslo, Tekn. Skr.* no. 1 N, 35 pp., 1951.

In the cases of circular or infinite cantilever plates, formulas may be derived in closed form for the deflections due to a concentrated load. A detailed derivation of these formulas is given, using the mathematical method of inversion. Graphical illustrations are given for curvatures, bending moments, twisting moments, and shears at chosen points. S. U. Benscoter, USA

803. Weiss, H. J., Prager, W., and Hodge, P. G., Jr., Limit design of a full reinforcement for a circular cutout in a uniform slab, *J. appl. Mech.* **19,** 3, 397–401, Sept. 1952.

A thin square slab with a central circular cutout reinforced by a concentric ring is subjected to uniform tension T_x and T_y on the exterior edges. It is desired to determine the dimensions of the reinforcement if the slab is not to collapse under any load which could be supported by a similar slab without any cutout or reinforcement. It is assumed that the slab and reinforcement are made of a perfectly plastic material which satisfies the Tresca yield criterion of maximum shearing stress, and that the dimensions of the reinforcement are such that it may reasonably be approximated by a curved beam. Under these assumptions, an upper bound on the necessary thickness of the reinforcement for any given radius is obtained. Certain practical limitations of the theory are discussed.
From authors' summary by T. H. H. Pian, USA

804. Belen'kiĭ, M. Ya., A mixed problem of the elasticity theory for an infinitely long strip (in Russian), *Prikl. Mat. Mekh.* **16,** 3, 283–292, May–June 1952.

Infinitely long strip $y = \pm 1$ is considered, displacements being given on part of boundary and normal stresses on the rest of it, shearing stresses vanishing at boundary. Applying Kolossoff-Muskhelishvili expressions for stresses and displacements by two functions of complex variable, author arrives at system of singular integral equations. Approximate method of solving it is indicated and applied to strip compressed by two absolutely rigid dies of finite length. J. M. Klitchieff, Yugoslavia

805. Czerny, F., On the influence of Poisson's ratio on the moment values of rectangular plates loaded transversely (in German), *Öst. Bauztschr.* **7,** 9, 150–153, Sept. 1952.

806. Ziemba, St., Full circular cylinder of finite length subjected to an axial compressive load (in Polish), *Arch. Mech. stos.* **3,** 2, 165–210, 1951.

This is approximate analysis but gives any desired degree of accuracy of actual distribution of stresses and strains in solid circular cylinder of finite length under action of axial concentrated forces. Calculation refers to both tension and compression, provided that, in case of compression, no additional phenomena, such as instability, occur. Author begins with fundamental equations of equilibrium of homogeneous body in Cartesian and cylindrical polar coordinates. First, Boussinesq's example is cited of semi-space under action of concentrated compressive force in a point of the boundary plane. By means of proper choice of harmonic stress function, following examples are calculated in all the details: Semi-infinite cylinder; finite cylinder with both normal and shearing stresses on its side surface; no shearing stresses on end cross sections, and arbitrary distribution of normal and shearing stresses on side surface; side surface free from any stresses, end cross sections free from shearing stresses (there exist only concentrated axial forces and normal stresses); no stresses of any kind on side surface and end cross sections, only axial concentrated forces. Equations are very complicated, but precision of calculation is impressive. Diagrams of stresses are included. M. Z. Krzywoblocki, USA

807. **Fletcher, H. J., and Thorne, C. J., Thin rectangular plates on elastic foundations,** *J. appl. Mech.* **19,** 3, 361–368, Sept. 1952.

The problem of a rectangular plate on an elastic foundation has already been treated by other authors, but with other boundary conditions. This paper treats the case with two opposite edges having prescribed moments and deflections and the other two edges having any of six boundary conditions. The method of solution here applied is known under the term "sine transform." Numerical results are given for the two edges clamped, free, and simply supported. Authors give, first, the value of the constants in the general solution for certain of the edge functions required to be zero. The values of constants for the edge functions not equal to zero are written in terms of the corresponding constants for the edge functions equal to zero. The factor, depending on the load, is evaluated for several specific examples. The curves for a special plate are plotted. L. Föppl, Germany

808. **Nylander, H., Initially deflected thin plate with initial deflection affine to additional deflection,** *Inter. Assn. Bridge struct. Engng.*, Repr. from *Publications* **11,** 347–374, 1951.

Starting from Marguerre's fundamental equations of an initially deformed thin plate [*Proc. 5th int. Congr. appl. Mech.* **V,** p. 93, Cambridge, Mass., 1939], author compares equations of the problem with the corresponding equations of an initially plane plate which, in comparison with the initially deflected plate, has the same extent in the plane but a different thickness and a different distributed load. Under certain conditions, i.e., by an appropriate choice of the thickness and load of the initially plane comparison plate, the fundamental equations for both plates are identical. Therefore, assuming initial deflection affine to additional deflection, the solution of the equations of the initially deflected plate can be obtained from the solution of the equations of the initially plane plate. By the above-mentioned confining assumption, the general problem of an initially deflected plate is considerably simplified. On the other hand, the most probable form of the inevitable initial deflection is difficult to determine in advance.

Five selected examples demonstrate the procedure of deducing the solutions for the initially deflected plate from previously known solutions for the initially plane plate. The examples comprehend rectangular and circular plates with various boundary conditions, the loads consisting of transverse loads acting perpendicularly to the plane of the plate or of (compression or shear) forces acting in the plane of the plate. The results are represented by diagrams showing deflections and stresses as functions of the load at various values of the initial deflection. In such way, besides the method of calculation, a good insight and many details of the effect of initial deflections are given; e.g., for a rectangular plate compressed in one direction and simply supported at all four edges, the extremely great influence of the initial deflection on the effective width of the plate is shown by the calculated stresses which, moreover, are compared with test values.

Considering the difficulty of the general problem, the method of solution and calculation is very simple. The knowledge obtainable from the paper is useful in drawing up design rules, in interpreting test results, and in the design of measuring instruments. E. Seydel, Germany

809. **Schäfer, M., On a refinement of the classical theory of thin, slightly bent plates** (in German), *ZAMM* **32,** 6, 161–171, June 1952.

Author derives the general equations of E. Reissner's theory of plates, which permits satisfying three boundary conditions in contrast to the two boundary conditions of classical plate theory. The problem of a rectangular plate with four free edges and carrying a double Fourier pressure distribution is discussed as an example of the Reissner theory. Author carefully discusses the differences between the two theories but, as stated in the introduction, the principal purpose of the paper is to present the Reissner theory to German scientists and engineers not familiar with it because it first appeared during World War II years. H. A. Lang, USA

Buckling Problems

(See also Revs. 737, 808, 846)

810. **Wang, C.-T., Ross, A. L., and Reiss, E. L., Prestressing rectangular thin plates to increase their buckling loads,** *J. aero. Sci.* **19,** 8, 568–569, Aug. 1952.

Note in Readers' Forum.

811. **March, H. W., and Kuenzi, E. W., Buckling of cylinders of sandwich construction in axial compression,** *For. Prod. Lab., U.S. Dept. Agric., Rep.* no. 1830, 42 pp., 1 table, 8 figs., June 1952.

In 1941, von Kármán and Tsien studied postbuckling behavior of a compressed homogeneous isotropic thin cylinder and found that, as compression proceeds, resistance drops precipitously from the classical value, reaches a minimum at a fraction of this value, and then increases; some attempt was also made to relate this minimum resistance to the observed maximum resistances of actual cylinders, although it is difficult to see what connection there is between them. The present paper is an interesting extension of von Kármán and Tsien's analysis to cylinders of sandwich construction, but again, apparently (the paper is not clear on this important point), the initial maximum resistance is ignored and the minimum resistance is interpreted as if it were the maximum resistance.

The paper represents some advance on other recent publications on this subject in the use of large deflection theory and the inclusion of the results of numerous tests. As with plain cylinders, the reduction in resistance achieved by this analytical sleight of hand is apparently of the same order as that due to defects in actual cylinders, so that a fair "check" with experiment is obtained. No reference is made to recent extensions of von Kármán and Tsien's work, such as reviewer's paper with Wan, described in AMR **4,** Rev. 635. L. H. Donnell, USA

812. **Bültmann, W., Solution of the plane buckling problem by iteration** (in German), *Stahlbau* **21,** 7, 112–117, July 1952.

The results of a paper by Chwalla and Jokish [title source, **14,** p. 33, 1941] are used to solve the buckling problem of a rod resting on a number of supports with various end conditions but with no forces acting at any point of its cross section. The rigidity measure is defined by $m = EJB/s$. E and J are elastic constants, s is length of rod, and factor B is given by α, $(1 - \beta/\alpha)$ $(\alpha + \beta)$, $(\alpha - \beta)$, $(\alpha + \beta)$, according as the two ends are elastically and rigidly fixed (m_e), or elastically and simply supported (m_g), or elastically fixed with symmetrical or asymmetrical bending (m_s, m_a). The values of α, β in terms of $\omega = s(S/EJ)^{1/2}$, S being the thrust, are taken from the afore-mentioned paper. Defining $\overline{m} = (B/EJ)m$ and relating the bending moments at the two ends by $\overline{M}ab = Mab$, the rigidity measures $\overline{m}_e$, $\overline{m}_g$, $\overline{m}_s$, $\overline{m}_a$ and the transformation factor C are tabulated and plotted against different values of ω. These calculations are carried out both for a rod under compression and for a rod under tension.

The buckling stress and the safety factor are now determined

from the criterion that the algebraic sum of the rigidity measures for the different portions of the rod vanishes. Four examples of rods supported at three or four points with various end conditions are worked out with the help of Hardy Cross iteration method, and good agreement is found with known results. For a compression rod supported at three points, the safety factor is found to be 3.03, and when it is symmetrically supported at four points, it becomes 2.66.

B. R. Seth, India

813. Boley, B. A., and Zimnoch, V. P., Lateral buckling of nonuniform beams, *J. aero. Sci.* **19**, 8, 567–568, Aug. 1952.

Authors present a numerical method for solving the problem of lateral buckling of a nonuniform beam submitted to pure bending in its plane. The procedure employing influence coefficients, described previously by the senior author [AMR **1**, Rev. 68; **4**, Rev. 4115], is adopted. The beam in question is replaced by an imaginary beam made up of a number of uniform sections. Three equilibrium equations may be written at each joint corresponding to the three degrees of freedom. The coefficients (defined as influence coefficients) of these equations contain the applied bending moment as a parameter. For a beam with n joints, there results a set of $(3n)$ simultaneous homogeneous linear algebraic equations, from which the critical bending moment can be determined. Authors also present results obtained for the other loading conditions.

T. H. H. Pian, USA

814. Kuranishi, M., Some recent investigations on the elastic stability of bars, *Rep. Res. Inst. Technol., Nihon Univ. Tokyo*, no. 1, 19 pp., July 1952.

Author considers relations between critical loads involved in various types of buckling. Effect of shear center location is discussed. Special cases lead to results of practical interest.

C. E. Pearson, USA

815. Seide, P., Derivation of stability criterions for box beams with longitudinally stiffened covers connected by posts, *NACA TN* 2760, 21 pp., Aug. 1952.

Paper is extension of analytical part of AMR **4**, Rev. 1144, to include beams with longitudinal stiffeners attached to covers on post lines. No numerical results are given.

K. H. Griffin, England

816. Radok, J. R. M., The theory of general instability of cylindrical shells, *Coll. Aero. Cranfield Rep.* 61, 16 pp., June 1952.

In this theory the homogeneous equations of the buckling of a cylinder are completed by right-hand-side terms which, through corresponding singularities, take count of discontinuities in solutions for concentrated loads in stringers and rings. The amplitudes of these right-hand functions are determined by homogeneous equations arising from the conditions of transition at the stringers or rings. Starting with a double Fourier series, the critical load must be determined by solving a determinant whose order depends on the number of terms considered. The theory, though simple in principle, leads to equations which are so complicated that author calculates only one case of little practical interest—the symmetric buckling of a shell with a single ring, the result being very near the well-known Lorenz formula.

K. Marguerre, Germany

817. Czulak, J., The stability of the two-hinged circular arch with vertical load (in Polish), *Arch. Mech. stos.* **3**, 2, 107–126, 1951.

Interesting contribution, from engineering standpoint, to stability of two-hinge circular arc loaded in its plane perpendicular to chord connecting its ends. It is based on Wierzbicki's method [*Drogownictwo*, Warsaw, 1946, 1947, 1948; title source, 1949, etc.] applied originally to parabolic arc. Initial point of method is well-known relation between variation of curvature of axis of a beam and bending moment. Arc is divided into number of intervals and above relation applied to each interval, thus giving a system of difference equations. A root of determinant of this system gives value characteristic for stability. Numerical example shows that circular arc is more stable than parabolic (calculated by Czulak, *Drogownictwo*, Warsaw, 1947). To calculate the stresses in cross section, Jasinski's formula is used. In Hooke's range, this is reduced to generalized Euler formula. In plastic range, instead of modulus of elasticity, a coefficient introduced by Wierzbicki [I.B.B., Warsaw, 1947] is used. Numerical example of stress distribution in circular arc in plastic range closes the paper. Reviewer's remark: Authors (Wierzbicki, Czulak) attack problem from engineering standpoint and seek a solution. But a difference system is always associated with some original fundamental differential or other system (one or more equations) lacking in present case. It is reviewer's impression that it can be derived. Discussion of it would contribute to general theory of arcs and methods of solution. Obviously, the above is one of possible approximation methods of solution of this unknown equation describing phenomenon of stability.

M. Z. Krzywoblocki, USA

818. Stevens, G. W. H., The stability of a compressed elastic ring and of a flexible heavy structure spread by a system of elastic rings, *Quart. J. Mech. appl. Math.* **5**, part 2, 221–236, June 1952.

The stability of an elastic ring compressed by a distributed radial load is investigated in detail. The change in the stability due to the first derivative in the radial direction of the distributed load is shown clearly, the ring becoming more stable if the loads tend to increase with an outward deformation. The case where the direction of the load remains radial and does not change with deformation, as well as the case where the load always acts normal to the ring, are considered. Author applies the results of the latter case to investigate in detail the stability of a hooped skirt.

G. V. R. Rao, USA

819. Hoff, N. J., The buckling of sandwich structural elements, Sherman Fairchild Publ. Fund Paper, Inst. aero. Sci. Prepr. 165, "Theory and Pract. of Sandw. Contr. in Aircr.," Symposium, 13–20, 1948.

Clear, much-needed review of the formulas available for the computation of buckling loads of sandwich columns and plates. Author discusses the hypotheses and range of applicability. Problems to be explored and discrepancies between the hypotheses and the physical reality, such as the skew ripple buckling, are indicated.

C. Riparbelli, USA

820. Norris, C. B., and Kommers, W. J., Critical loads of a rectangular, flat sandwich panel subjected to two direct loads combined with a shear load, *For. Prod. Lab. Rep., U.S. Dept. Agric.* no. 1833, 19 pp., 2 tables, 10 figs., June 1952.

By using the energy method, an approximate formula is obtained for the critical load of a rectangular flat sandwich panel subjected to two direct loads applied perpendicularly to its edges, combined with a shear load applied parallel to its edges. The plate may have either simply supported or clamped edges. Tests of 45 sandwich panels having aluminum facings and cores of end-grain balsa wood, cellular hard rubber, or cellular cellulose acetate show that the experimental critical loads agree reasonably well with those computed by the formula.

C. T. Wang, USA

821. **Jones, B. D., A theory for struts with lattice or batten bracing,** *Struct. Engr.* **30,** 5, 108–113, May 1952.

Author analyzes the problem of the crippling of lattice struts, including the effects of deflection due to shear deformation. Several examples are discussed and solved. Expressions for shear stiffness of the usual forms of light shear bracing, such as lattice bracing, with and without posts, and batten bracing with equal and unequal chords are given. William J. Carter, USA

Joints and Joining Methods

(See also Revs. 873, 886, 893, 906)

822. **Nelson, F. G., Jr., and Howell, F. M., The strength and ductility of welds in aluminum alloy plate,** *Welding J.* **31,** 9, 397s–402s, Sept. 1952.

Paper presents data accumulated over a period of several years on the strength and ductility of welds made in aluminum alloys by the argon-shielded tungsten-arc method and the semiautomatic and automatic argon-shielded consumable-electrode methods. The data consist of tensile strength and free-bend elongation of butt welds and shear strength of longitudinal and transverse fillet welds. The aluminum alloys are those most commonly used by commercial fabricators, including five nonheat-treatable alloys (2S, 3S, 4S, 52S, and XA54S), and the heat-treatable alloy 61S. The filler wires used were generally 43S alloy or parent metal.

From authors' summary

823. **Thielsch, H., Welding processes and procedures employed in joining stainless steels,** *Weld. Res. Counc. Bull. Ser.* no. 14, 48 pp., Sept. 1952. $2.

A review of published and unpublished information on metal-arc welding, carbon-arc welding, gas welding, resistance welding, and oxygen cutting. Author discusses welding characteristics and procedures, preparation of base steel, jigs and fixtures, welding technique, defects in welded joints, cleaning of welded joints, mechanical properties, and applications.

From author's summary

824. **Funk, E. R., and Udin, H., Brazing hydromechanics** *Weld. Res. Suppl.* **17,** 6, 310s–316s, June 1952.

The forces governing the flow of a brazing metal in a joint are calculated, and an equation for the time needed to fill the joint established. Main parameters are clearance of the joint, surface tension, and viscosity of brazing metal. The detrimental effects of variable clearance along the joint are explained and the influence of the flux discussed. Examples for horizontal and vertical joints are given. E. Haenni, Switzerland

825. **Bertossa, R. C., High strength vacuum brazing of clad steels,** *Welding J.* **31,** 10, 441s–447s, Oct. 1952.

Article describes new brazing process producing high-strength joints having uniform and continuous bonding over large areas without the use of fluxes or special furnace atmospheres. Metallurgical characteristics and mechanical properties of vacuum-brazed joints are discussed. Article presents no information on details of equipment and techniques for vacuum brazing. Process is stated to be capable of producing composite metallic materials which meet ASTM-ASME requirements for integrally and continuously bonded clad plate for use in pressure-vessel fabrication. F. J. Winsor, USA

826. **Corelli, R. M., Modern synthetic resin adhesives, their characteristics and use in aeronautical structures** (in Italian), *Aerotecnica* **32,** 1, 8–19, Apr. 1952.

827. **Knight, R. A. G., Adhesives for wood,** New York, Chemical Publ. Co., Inc., 1952. xi + 242 pp. $5.

Author draws upon his own wide experience and upon the very considerable body of literature, to provide an excellent, compact treatment of the subject which is based upon laboratory research and upon observations made in practice. The principal portions of the book are devoted to a general discussion, the factors involved in gluing technique, a survey of conditions under which adhesives are used, and the testing of adhesives. The book is, therefore, useful both to the user of adhesives for wood and for the engineer or other person seeking information regarding the properties of such adhesives and their best use. This is particularly true of the discussion of weather resistance and the relative durabilities of various adhesives under different conditions.

A. G. H. Dietz, USA

828. **Eickner, H. W., Olson, W. Z., and Blomquist, R. F. Effect of temperatures from −70° to 600° F on strength of adhesive-bonded lap shear specimens of clad 24S-T3 aluminum alloy and of cotton- and glass-fabric plastic laminates,** *NACA TN* 2717, 26 pp., June 1952.

Tests were made to determine the high-temperature behavior of various commercial adhesives used to bond lap shear specimens of clad 24S-T3 aluminum alloy, and of cotton- and glass-fabric laminates. In some instances, the materials were bonded to themselves, and, in others, were bonded to each other. Test temperatures ranged from −70 to 600 F.

From the standpoint of temperature resistance up to 450 F, the most promising commercial adhesive was a tape which appeared to be a formulation of phenolic resin and synthetic rubber. This could be used for some types of bonds at these temperatures. Only one adhesive showed promise for bonding all materials to themselves and to each other, and this one was limited to temperatures below 250 F. Shear strengths were much more affected by elevated temperatures than by low temperatures.

This study is valuable in casting considerable light on the behavior of a series of different types of commercial adhesives employed for making high-strength bonds between engineering materials of the type commonly employed in aircraft and similar constructions. Its chief value lies, perhaps, in pointing out that a great deal of work remains to be done in the development of adhesives which are suitable for high-temperature applications.

A. G. H. Dietz, USA

Structures

(See also Revs. 738, 795, 803, 812, 817, 821, 908, 910, 1106, 1112, 1141)

829. **Blaise, P., Elementary formulas for the calculation of beams, arches, and portals** (in French), *Ann. Ponts Chauss.* **122,** 4, 407–461, July/Aug. 1952.

Methods for the calculation of hyperstatical systems with average plane usually resort to the infinitesimal calculations, and the distribution of stresses is often represented by Green's function, which implies outside stresses, all of them in a parallel direction and applied on the center line of web.

Present paper gives, within the frame of Ritter's method, some formulas which can be used immediately for the calculation of beams, arches, and portals with average plane, whatever their design, and the law of variation of the straight sections and systems of force being applied in the average plane to the various sections of beams and arches.

It had to be assumed that the distribution of forces and elastic properties were discontinuous in order to maintain the study on a

level with the difficulties encountered in elementary courses of mathematics.

The formulas attained by the author are particularly adapted for the calculation of influence lines.

From author's summary by C. M. Smith, USA

830. Müllenhoff, A., and Heilig, R., New method for analysis of statically indeterminate girders and rigid frames (in German), *Stahlbau* **21**, 7, 105–111, July 1952.

Paper is based on three articles in *Eng. News-Rec.* (1944 and 1945) by D. B. Steinman and gives a summary with some complementary observations. Method is a combination of Cross method with method of distribution of deformations, and requires only one relaxation of each joint; it is called method of "couples rigidities." After an introductory section on simple graphical procedures for determining end moments of beams clamped at both ends, the method of coupled rigidities is demonstrated, both in graphical and in numerical form, and illustrated by examples. A final section discusses simplifications which are made possible with symmetrical structures by splitting the loading in symmetrical and antisymmetrical parts.

F. J. Plantema, Holland

831. Wehle, L. B., Jr., and Lansing, W., A method for reducing the analysis of complex redundant structures to a routine procedure, *J. aero. Sci.* **19**, 10, 677–684, Oct. 1952.

See AMR **5**, Rev. 2594.

⊛832. Stewart, R. W., and Kleinlogel, A., The traverse method [Die Traversen-Methode], Berlin, Wilhelm Ernst & Sohn, 1952, 108 pp., 167 figs., 6 tables. DM 17.50.

Book is German revision of "The traverse method in stress analysis" by Ralph W. Stewart [mimeogr., 91 pp., published by the author, Los Angeles, 1948, $5]. The latter, in turn, was based on four papers by Stewart appearing in *Trans. ASCE*, 1936, 1939, 1945, 1949.

Traverse method, moment distribution, and slope-deflection method all occupy the same general field of structural analysis. Traverse method is supposedly the most general of the three in that it will solve some problems not solvable by the others.

Kleinlogel is introducing, transposing, and improving on original English work. Most examples were retained, but with modifications and clarifying explanations. Some new examples are added, and the number of tables of constants reduced. Reviewer believes presentation is much improved over original.

M. W. Jackson, USA

833. Ghaswala, S. K., Models and analogies in structural engineering, *Civ. Engng. Lond.* **47**, 547, 548, 549, 550, 551, 552; 54–56, 134–136, 225–227, 315–317, 404–406, 488–489; Jan., Feb., Mar., Apr., May, June 1952.

Author surveys methods of stress analysis applicable to the field of structural engineering. Although the paper is comprehensive in its coverage, the discussion of each method is necessarily quite brief. An excellent bibliography is included.

H. Simpson, USA

834. Wyly, T., The equivalent joint method of rigid frame analysis, modification of slope deflection by successive approximations, *Bull. Amer. Rly. Engng. Assn.* **54**, 502, 8–44, June/July 1952.

Author is concerned with effect of variations in cross section of members of rigid frames at joints produced by gusset plates and merging of girders and columns upon bending moments produced. He leaves for "experimental investigation" the all-important ratio between the moment of inertia of the gusset plus that of member to that of member only. This ratio, referred to as r, while often highly variable for a given member within any one joint, the author implies to be constant. Despite the fact that r may approach infinity (as when girders and columns merge), author suggests a minimum value of 5 for r. No reason is deduced for this arbitrary value. Result: Lengthy analysis is dependent upon unknown value of r.

In the case of reinforced concrete—the material in which continuity is usually encountered—author has not considered the effect of cracking or the chance (and often large) variations in the modulus of elasticity. Reviewer cannot agree with author's statement which opens the paragraph headed Analysis. Values of FEMs, stiffnesses, and carry-over factors for all practical variations in moments of inertia and loading have long been available in tabular and/or graphical form, permitting rapid solution of such problems by moment distribution (or by trial solution of the equations of slope deflection). Moments thus obtained can then be corrected to faces of members very simply.

Reviewer feels author's use of "clear" span has clouded rather than cleared the issue. In view of foregoing, reviewer is of opinion that the paper possesses little research value.

A. H. Finlay, Canada

835. Tischer, W., Standardized design of small-span highway bridges (in German), *Bauingenieur* **27**, 7, 225–264, July 1952.

Report presents in detail a procedure developed since 1946 for standardizing and simplifying the design of the smaller highway bridges required to replace those destroyed in Germany during World War II. The primary requirements were that the structures be economical to construct, and attractive. The basic structure consists of a reinforced-concrete deck supported on a series of longitudinal steel girders connected by transverse steel beams. Designs cover a range of loads, spans, and types of traffic. The process of design is carried out by successive use of a series of tables by means of which is found the design most appropriate to a given set of initial conditions.

M. P. White, USA

836. Werren, F., Shear-fatigue properties of various sandwich constructions, *For. Prod. Lab. Rep., U.S. Dept. Agric.* no. 1837, 4 pp., 1 table, 4 figs., July 1952.

837. Werren, F., Fatigue sandwich constructions for aircraft. (Aluminum facing and expanded-aluminum-honeycomb core materials tested in shear), *For. Prod. Lab. Rep., U.S. Dept. Agric.* no. 1559-K, 4 pp., 1 table, 1 fig., July 1952.

A limited number of tests were made to determine the shear-fatigue properties of a sandwich panel with aluminum facings and a core of expanded aluminum honeycomb. Repeated tests were made at a ratio of minimum to maximum loading of 0.1.

With adequate core-to-facing bonds, the construction tested had a fatigue strength in the LR plane at 30 million cycles of about 38% of the static strength for the condition of loading used.

From author's summary

838. Hill, G. T. R., Advances in aircraft structural design, 3rd Anglo-Amer. aero. Conf., Brighton, Sept. 4–7, 1951. London, Roy. aero. Soc., 1–24.

Paper reviews the development of airplane structures and structural analysis. Reference is made to the failure of Langley's tandem monoplane as the first crash due to divergence, and to Handley Page 0.400 as the plane which first showed flutter. Author believes that the Pterodactyl tailless plane, designed by himself in the 1920's, was the first plane to have sandwich fuselage. Description of the Hill aero-isoclinic wing is also given.

N. J. Hoff, USA

839. **Gordon, J. E., Plastics and plastic structures,** 3rd Anglo-Amer. aero. Conf., Brighton, Sept. 4–7, 1951. London, Roy. aero. Soc., 177–198.

Author describes program of developing plastic wings at Royal Aircraft Establishment. He advocates use of chrysotile asbestos fibers in preference to glass fibers, and phenolic resins to polyesters. With random orientation of comparatively short asbestos fibers, ultimate tensile strength of 20,000 psi and Young's modulus in tension of 2.4 × 10 psi were reached at specific gravity of 1.27. Design details of nontapered straight wing and delta wing are given. Plastic wings were stronger and stiffer than equal-weight metal structures. N. J. Hoff, USA

840. **Hall, H. W., and Hughes, T. P., Some material problems of high-altitude aircraft,** 3rd Anglo-Amer. aero. Conf., Brighton, Sept. 4–7, 1951. London, Roy. aero. Soc., 593–612.

Paper represents a study of problems encountered with various nonmetallic materials at high altitudes. Vapor lock and loss of fuel caused by boiling at low pressure are discussed and preventive measures are suggested. A thorough study is given of the crazing of transparent plastics. Crazing is the appearance of scratches on the surface of a plastic which are found to be consequences of local tensile failures near the surface. Crazing occurs at low temperatures if tensile stresses and solvent are present simultaneously. Difficulties encountered along edge of canopies, reinforcements, and sandwich construction introduced to eliminate explosive failures are discussed. N. J. Hoff, USA

841. **Blinkhorn, J. W., Landing gear with twin tandem wheel units: Cornering characteristics as determined by model tests,** *Aero. Res. Counc. Lond. Rep. Mem.* 2668, 7 pp., July 1948, published 1952.

For twin tandem units, the wheel loading conditions which arise when aircraft are turned on the ground may be critical for the landing gear. To estimate the magnitude of these loads, cornering tests were made on a small-scale model of the main undercarriage unit. These tests showed that for zero turning radius, i.e., turning about the central vertical axis of the model undercarriage, the wheel side loads were almost equal to the vertical load multiplied by the coefficient of sliding friction between the tires and the ground. The side loads rapidly decreased as the turning radius increased, and with the turning radius equal to three times the wheel base, the wheel side loads were only about half of those at zero turning radius. The severity of the design loads for turning on the ground will, therefore, be considerably reduced if it can be insured that the center of the minimum turning circle of the aircraft is a short distance outboard of either main undercarriage unit. From author's summary

842. **Winkel, R., Effect of backwater behind retaining walls on the magnitude of earth pressure** (in German), *Bautechnik* **29**, 7, 190–192, July 1952.

Author gives a simple method to compute pressure of a partially or totally submerged granular backfill on a retaining wall. Below water level, total pressure is obtained as sum of full hydrostatic pressure and earth pressure computed with submerged weight of soil and corresponding coefficient of internal friction. Submerged weight is easily determined, if void ratio is known. E. Rathgeb, Argentina

843. **Marquardsen, R. P. V., Practical design of thin retaining-wall footings,** *J. Amer. Concr. Inst.* **24**, 1, 45–56, Sept. 1952.

On the assumption of a constant modulus of subgrade reaction, author presents approximate formulas for determining the bending moments and shearing forces in slab foundations. The method, which is illustrated by an example, is of limited use in practice because the subgrade modulus of many soils varies with the intensity of pressure and size of the loaded area. G. G. Meyerhof, England

844. **Tölke, F., Development in the construction of dams, especially rock-fill and concrete dams** (in German), *Wasserwirtschaft* **42**, 4, 89–120, Jan. 1952.

Paper, divided into 7 parts, begins with a clear and objective explanation of the importance of dams in the field of flood control, irrigation, water supply, and electric power, giving examples from many countries, especially the United States and Germany. In the second part, author describes the influence presented in the choice of the structural type of dams by conditions of site, foundations, and spillways, and the changing and shifting of their relative importance noted with the advancement of techniques, illustrating his statement with many interesting and characteristic examples. For rock-fill dams, the favorable effect in compaction of a new heavy vibrator (Mammut-Rüttler), utilization of a high-frequency vibration equipment in the construction of impervious concrete facing, and use of asphalt and sheets of plastics as impervious membrane are explained in great detail. In case of concrete dams, author restricts his study to the arched and buttressed types of dams, considering the solid gravity types as having attained for many years, the last stage. Many examples of arch dams are analyzed (Jorgensen type, cylindrical and warped surface shells), including a study of movable joints, with an original suggestion of the author for the construction of concrete-asphalt movable joints (Bitumenbetonkissen). In part 3, author deals with the problem of cracks, principally in gravity dams. In part 4, the problem of construction joints is explained, with solutions adopted in the United States and Europe. Part 5 reports the progress made in designing concrete mixes, considering new methods and equipments available for their consolidation, and consequent adaptation to construction methods. In part 6, the cement problem is treated, and, finally, a brief explanation is made about the methods and equipment for model analysis and strain measurements in dams. I. Wolff, Brazil

845. **Hognestad, E., Fundamental concepts in ultimate load design of reinforced concrete members,** *J. Amer. Concr. Inst.* **23**, 10, 809–828, June 1952.

Paper brings together ultimate load-design equations for flexure, axial compression, and combinations thereof, together with some interesting historical background on these areas. Knowledge of diagonal-tension ultimate strength is outlined and evaluated as limited. Ultimate bond strength is presented briefly as "hardly a serious problem" with deformed bars until a yield point above 50,000 psi is specified. (Reviewer cannot concur in complacency with respect to bond.)

Author strongly favors design that insists upon ductile-type failures (tension in steel) and avoids such brittle-type failures as come from diagonal tension or flexural compressions; he does not approve of "truly balanced design" in which brittle-type failure may be equally probable. P. M. Ferguson, USA

846. **Nash-Gower, V. H., Columns subjected to bending in two directions and with axial loads,** *Concr. Constr. Engng.* **47**, 8, 233–236, Aug. 1952.

In reinforced-concrete columns subjected to bending in two directions, tensile forces act over part of section, rendering ordinary design procedures incorrect, because fundamentally this material is considered anisotropic under such conditions. Exact analytical solutions are generally cumbersome and graphical methods have to be resorted to. The latter process is carried out

in three steps: (1) Finding the direction of neutral axis, based on Land's method; (2) finding the position of neutral axis based on Guidi's; and (3) finding values of stresses by simple equations. Accuracy of this method is governed by exactness in graphical manipulations. S. K. Ghaswala, India

847. Brandes, G., On the stress determination in reinforced-concrete arches (in German), *Bauingenieur* **27**, 7, 265–268, July 1952.

Author reviews two methods generally used for determining stresses in cracked cross sections under variable load conditions: (1) Influence lines for maximum compressive stress at one edge and maximum tensile stress at opposite edge of uncracked sections are used; next, fictitious normal force and bending moment corresponding to these stresses are derived and, from these, stresses in cracked section determined. Method is inconsistent because stresses in uncracked section do not occur simultaneously. (2) Largest moment around axis of section and normal force acting under same loads are used for determining stresses in cracked section. In both (1) and (2), most unfavorable position of load is not found. (3) Correctly, moment round center of tensile reinforcement must be used to compute compressive stress at opposite edge and moment round center of compression in concrete plus steel for stress in tensile steel. Method is said to be unfeasible because position of neutral axis is unknown; reviewer, however, suggests considering an approximation based on estimating center of pressure. Author recommends modified method (1a) based on maximum compressive stress at one edge and simultaneously acting tension at other edge, and vice versa. Methods (1), (2), and (1a) are compared for an intentionally extreme example; large deviations are found, (1a) giving best values. As neither method is based on correct load position, largest values are nearest to reality.

H. Craemer, Germany-Egypt

848. Brice, L.-P., Theory of cracking of members in reinforced concrete. Practical consequences (in French), *Ann. Inst. tech. Bât. Trav. publics* **5**, 54, 585–600, June 1952.

Methods are proposed for calculating the width and distribution of cracks in reinforced concrete, and applications are made of these calculations to various practical problems, such as the determination of the maximum allowable stress in steel reinforcement.

Basic assumption is that, after cracking has begun, bond between steel and concrete may be regarded as a frictional stress acting in the opposite direction to the displacements and is constant along a bar. Other matters treated are deformations in tensile reinforcing steel under cycles of load, stress distribution on bars of different diameters, and the effective value of modular ratio.

Main difficulty in application of this theory admitted by author is reliable determination of frictional resistance. Author is apparently not familiar with earlier work on this subject; in particular, paper by A. Johnson [see AMR **4**, Rev. 2904] which is almost identical with fundamental part of author's work. Johnson uses same assumption regarding distribution of bond stress, but discusses other possibilities; however, neither Johnson nor author considers experimental distribution as given by Hawker and Evans [AMR **5**, Rev. 2340]. F. A. Blakey, Australia

849. Samuely, F. J., Some recent experience in composite pre-cast and in-situ concrete construction, with particular reference to pre-stressing, *Proc. Instn. civ. Engrs.* **1**, 2, part III, 222–259, Aug. 1952.

Precast concrete is now being developed for beams, columns, and space frames in Europe. The advantages and disadvantages of precast concrete as compared to in-situ concrete construction are summarized. Author believes that composite constructions of precast and in-situ concrete retain most of the advantages of both in-situ and precast construction. Factors to be considered in the design of composite concrete connections and precast units are discussed in detail. Recent applications of composite prestressed-concrete construction in Great Britain and on the continent are described. Reviewer believes that article adds to the growing fund of information concerning prestressed-concrete design and prestressed-concrete construction practice.

James A. Cheney, USA

850. Coepijn, W. C., Load tests of prestressed-concrete beams for a viaduct at Rotterdam (in Dutch), *Ingenieur* **64**, 30, Bt.45–Bt.52, July 1952.

Paper gives the general features of a viaduct made of prefabricated prestressed-concrete beams, then describes in detail the load tests made on two of these beams. The main conclusions of these tests are: (1) Test results are in good accordance with a theoretical analysis made previously by the same author [see AMR **5**, Rev. 2339], if the necessary data are read on the experimental (σ, ϵ) diagrams of the materials, and if the value for $\epsilon_{rupture}$ of the concrete is taken as 1.5 times the value deduced from the corresponding (σ, ϵ) diagram. (2) Results of the experimental study demonstrate the desirability for calculating the fracture moment by two different formulas, according to which of the two materials, concrete or steel, is the weaker. (3) It is very important to standardize the concept of prism strength by choosing specimens of a definite slenderness ratio.

Ch. Massonnet, Belgium

851. Magnel, G., Continuity in prestressed concrete, London, Cem. Concr. Assn.; Sympos. Prestress. Concr. Static. Indeterm. Struct., no. 4, 10 pp., Sept. 1951.

Author explains the reasons why it is unavoidable to make continuous statically indeterminate structures in prestressed concrete, and states the theoretical and practical difficulties in connection with this. Some examples of statically indeterminate prestressed structures constructed in Belgium are given; these include a two- and a four-story building and the bridge across the river Meuse, which is the most important application of continuity made up to the present in bridge building.

Paper ends with an appendix giving some results of measurements of the loss of stress due to friction.

From author's summary

852. Kee, G. O., Continuity using post-tensioned high-tensile alloy steel bars, London, Cem. Concr. Assn., Sympos. Prestress. Concr. Static. Indeterm. Struct., no. 6, 11 pp., Sept. 1951.

Paper discusses briefly the theoretical and practical problems associated with continuity and the advantages which can be derived from it, particularly where precasting is used. The technique of using bars is considered, and mention is made of the use of couplers, which opens new fields of application.

Methods of achieving continuity are described, with particular reference to continuous beams and portals, both precast and cast in situ. Relevant equations are also given. Other constructions such as multistory frames are also described.

From author's summary

853. Abeles, P. W., Partially prestressed concrete constructions, built in the Eastern Region of British railways 1948–1952, *Publ. int. Assn. Bridge struct. Engng.* **12**, 1–13, 1952.

Four types of structures are discussed, and the essential fea-

tures of partial prestressing are pointed out, particularly its economy, increased resilience, and capacity of giving an early visible warning of overloading. Reference is made to static loading tests to failure in 1949 to 1951 and to fatigue tests carried out at Liège in 1951. Routine tests to investigate the quality of products are described, and examples of practical application are given of 16 road bridges over railways of spans 20–50 ft, built as composite partially prestressed slabs. Another example relates to a roof construction in which large partially prestressed beams were used for the first time. From author's summary

854. **Cooper, G. S., The influence of multiple-wheel undercarriages on the design and evaluation of airfield pavements,** *Proc. Instn. civ. Engrs.* part II, 1, 2, 419–447, June 1952.

Paper opens with a brief history of airfield-pavement construction and design methods, and shows how the multiple-wheel undercarriage was introduced in an effort to reduce the loading effect of very heavy aircraft on pavements. The expression "equivalent single-wheel load" is defined. Failure of pavements, both flexible and rigid, is discussed, and the effect of interaction of stresses caused by multiple wheels described. Methods are then given for the computation of equivalent single-wheel loads on flexible and rigid pavements, and the application of the equivalent single-wheel load in pavement design and evaluation is discussed.

Graphs are presented for (1) derivation of equivalent single-wheel loads on different thicknesses of rigid pavement, and (2) for showing the variation of equivalent single-wheel load with pavement thickness, on flexible and on rigid pavements, for several typical aircraft.

From author's summary by V. P. Zimnoch, USA

855. **Cochrane, R. H. A., The design of aerodrome pavements,** *J. Instn. Engrs., Austral.* **24,** 6, 129–137, June 1952.

Author presents methods of analysis for flexible and rigid airfield pavements used in Australia. Analysis of subgrade materials is based largely on CBR (California Bearing Ratio) test data. Design curves for flexible pavements are based on U. S. Corps of Engineers data. For rigid pavements, a formula has been worked out to give the relation between the stress in the extreme fiber, thickness of slab, wheel load, radius of contact area, and Westergaard's modulus of relative stiffness. Modulus of subgrade reaction is obtained from a correlation curve with CBR test data. In general, the practice parallels that of the United States. M. V. Smirnoff, USA

856. **Reinig, A., Balancing moments in braced purlins through predetension** (in German), *Stahlbau* **21,** 6, 95–98, June 1952.

In general, the economy of roof structures increases with the spacing of trusses. The latter is limited by increasing size of purlins, especially by permissible maximum deflection. Usually, this inconvenience is encountered in design by continuity of purlins achieved by cantilever scheme (Gerber). Author's proposal (patent applied for) reduces and equalizes (balances) positive and negative bending moments of purlins by knee braces, with such arrangement of continuous purlins over the upper chord of the roof truss that lifting (predetensioning) or sinking (pretensioning) of the supports is possible. This arrangement consists primarily of supporting gusset plates with vertically extended holes for bolts or rivets, permitting artificial vertical deflections. These deflections are calculated in every individual case to attain economical balance of bending moments. Example no. 1 shows 40% saving of steel in purlins (truss-spacing, 33 ft), with predetensioning of 0.3-in. average; example no. 2 with 19-ft spacings, 38% savings, with 0.16-in. predetensioning. J. J. Polivka, USA

857. **Gruber, E., The exact membrane theory of prismatical structures composed of thin plates** (in German), *Publ. inter. Assn. Bridge struct. Engng.* **11,** 129–164, 1951.

Paper concerns question as to what extent it is justifiable to calculate prismatical structures, composed of thin plates, according to the ordinary theory of the bending of bars, when the heights of the separate plates are large in comparison with the lengths. Assuming that the two stiffening diaphragms are absolutely rigid in their plane and can bend freely in a direction normal to that plane, author develops an exact calculation scheme by means of Airy stress function. The solutions are given in the form of Fourier series. Author gives a numerical application for a saw-tooth roof with a simple external loading. The results show that the deviations from the ordinary methods of calculation are small. Besides this practical example, attention is paid to the convergence of the Fourier series used and to the influence of divergence points of the external load. M. Kuipers, Holland

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 783, 796, 890, 913, 917, 942, 1037)

858. **Nye, J. F., Experiments on the plastic compression of a block between rough plates,** *J. appl. Mech.* **19,** 3, 337–346, Sept. 1952.

Paper describes experiments designed to check the theory of Hill, Lee, and Tupper on the compression in plane strain of a rectangular block between rough plates. The theory dealt with an ideal material having a well-defined yield point, no strain hardening, and which remained isotropic throughout the straining. To approximate these conditions, the author used tellurium lead suitably heat-treated. This did not possess the sharp yield point required; but the experimental results, even so, fairly well confirmed the theory. The distortion in the central plane was found by cutting the unstrained block in half and marking the interface with a grid, which was examined after straining. The theory predicts very well the way the pressure on the plate varies with the amount of compression. W. M. Shepherd, England

859. **Inoue, N., Some cases of the axially symmetric flow of perfectly plastic materials,** *J. phys. Soc. Japan* **7,** 5, 512–518, Sept./Oct. 1952.

Equations for plastic states of stress in a solid of revolution are established under the assumption that the circumferential principal stress is equal to one of the other two. Reviewer thinks that this assumption, which has been put forward by previous authors, is not valid [see R. Hill, "Plasticity," O.U.P., page 180]. Some applications of these equations are given, but no attempt is made to check the validity of the assumptions by considering the velocity components. W. M. Shepherd, England

860. **Inoue, N., A new method of solution of the two-dimensional isostatical problem in the mathematical theory of plasticity,** *J. phys. Soc. Japan* **7,** 5, 518–523, Sept./Oct. 1952.

Author finds what plastic problems are solved by a few simple solutions of Chaplígin's equation, making use of the analogy between plasticity and supersonics in AMR **5,** Rev. 1712. The method is interesting, but as yet has solved only one problem unsolved by other methods. It merits further investigation.

D. R. Bland, England

861. **Kochendörfer, A., Resistance to creep and its connection with other strength properties, considered physically** (in German), *Arch. Eisenhüttenw.* **23,** 5/6, 183–192, May/June 1952.

Author discusses the plastic stress-strain relations of single

crystals, and the dependency of the critical shear stress and rate of hardening on the temperature and deformation velocity. The importance of the propagation of small regions of slip is pointed out.

Author applies results to the behavior of polycrystalline material and investigates the possibility of influencing the creep curve and creep resistance. J. P. Benthem, Holland

862. Jenkins, C. H. M., and Tapsell, H. J., Factors influencing the creep resistance of wrought carbon steels, *J. Iron Steel Inst.* **171**, part 4, 359–371, Aug. 1952.

Paper is a summary of work at the National Physical Laboratory between 1929 and 1948 on effects of various manufacturing and other metallurgical variables on creep rate of carbon steels at 450 C, as measured in tests of 2 to 8 days under a stress of 8 tons per sq in. Attention is devoted to effects of composition, mode of manufacture, and heat treatment.

Reviewer is skeptical that reliance should be placed on tests of such short duration for rating steels as to load-carrying ability in long-time service at elevated temperatures.

G. V. Smith, USA

863. Jaoul, B., and Crussard, C., Relation between tensile and creep deformations and recrystallization (in French), *Metallurgia ital.* **64**, 5, 175–179, May 1952.

A thorough analysis of the stress-strain diagrams of tensile tests with pure aluminum and aluminum alloys reveals that, in the beginning of the permanent deformation, the glidings expand within the grains and cause a strain-hardening effect at the grain boundaries. It is also possible that the glidings are blocked by the impurities dissolved in the metal; the result is a strain-hardening effect within the crystals. The more numerous the dissolved impurities, the greater the importance of the last-mentioned hardening effect; it will correspondingly diminish the relative strain-hardening effect at the grain boundaries. If the strain hardening at the grain boundaries has reached a certain value, the crystal grains begin to divide. In case of major deformations, growth of the strain hardening is always due to processes within the crystals in conjunction with a division of the grains. The same observations can be made with creep tests. In case of a small load, the extension produces a mixed inter- and intracrystalline strain hardening which counteracts the progress of deformation. If we increase the load, the limit for intercrystalline strain hardening will be surpassed and the grains will be split up. The deformation mechanisms as described above are confirmed by the fact that an annealing process, applied after cold working, results in the formation of crystal nuclei. Recrystallization is possible only if the cold-working process results in a destruction of the structure grains, so that the thus formed parts may serve as recrystallization nuclei. E. Siebel, Germany

864. Green, L., Jr., Correlation of creep properties by a diffusion analogy, *J. appl. Mech.* **19**, 3, 320–326, Sept. 1952.

For creep deformation obtained not as a result of slip, a creep-time temperature relation is derived by employing the same concepts of statistical mechanics. Assuming that the creep-time relation follows a power law, or $e = Ct^a$, and observing that the exponent a varies linearly with the reduced temperature $T_d = T/T_m$, author shows that for constant stresses

$$e = (2Qt/Nh)^{T_d} \times \exp(-Q/RT_m)$$

where e is creep strain, R gas constant, h Planck's constant, N Avogadro's number, t time, T_m melting temperature in K, T absolute temperature, and Q the activation energy, which is the only unknown to be determined. However, the experimental results showed that the activation energy Q varied linearly with the applied stress for a certain absolute temperature; also, the activation energy at zero stress varied linearly with the reduced temperature.

The influence of various factors such as alloying elements, impurities, grain size, strain history, surface conditions, and radiation effect are discussed qualitatively. Ling-Wen Hu, USA

865. Dahlquist, C. A., and Hatfield, M. R., Constant stress elongation of soft polymers: time and temperature studies, *J. Colloid Sci.* **7**, 3, 253–267, June 1952.

Creep data under constant tensile stress are given for polyisobutylene and GR-S rubber for time from 0.01 to 10 min and temperatures from −50 to +40C. Data are transferred to single curves of log-reduced modulus vs. log-reduced time. Polyisobutylene data superpose satisfactorily with single activation energy in the reduction operation. GR-S data require, for good superposition, an activation energy which increases with modulus.

Reviewer believes authors use modulus definitions too simple for elongation range covered, up to 200%. Apparent variable activation energy of GR-S may result from this inadequate definition. Melvin Mooney, USA

866. Koehler, J. S., The nature of work-hardening, *Phys. Rev.* (2) **86**, 1, 52–59, Apr. 1952.

Author considers recent data on stress-strain curves of pure aluminum single crystals [Rosi, F. D., and Mathewson, C. H., *J. Metals* **188**, 1159, 1950] plus electron microscope data on pure polycrystalline aluminum showing slip zones of measurable thickness and separation [Brown, A. F., "Metallurg. applicat. of the electron microscope," Inst. Metals, p. 110, 1950]. Data obtained cover temperature range from about 100 K to 500 K.

Equations of stress-strain curves are derived on basis of finite strength of Frank-Read [Frank, F. C., and Read, W. T., title source, **79**, 722, 1950] dislocation sources, a given proportion being used up at each successively higher stress. Quantitative analysis is presented, based on a derived distribution of free lengths of dislocations, assumed to be valid for low density of dislocations, i.e., small strains. Such hardening by elimination of glide sources is called source-hardening.

Hardening at higher strains is discussed qualitatively in terms of locking of dislocations active in different slip systems when these systems cross. It is referred to as interaction hardening, active only at high strains. Source-hardening is assumed to continue in region of high strain.

Effect of increasing temperature to increase glide per source is discussed in terms of electron-microscope data. Author assumes that higher temperatures allow locked portions of dislocations to migrate to new glide planes. He considers finite limit to glide occurs when sufficient jogs in dislocation loop prevent further expansion of such loops.

Paper should be highly stimulating to persons in field of applied mechanics wishing to attain familiarity with implications of recent theories on metal imperfections. Several proposals for needed experiments are given. H. I. Fusfeld, USA

867. Read, W. T., Jr., Experimental information on slip lines, "Imperfections in nearly perfect crystals," New York, John Wiley & Sons, Inc., 129–146, 1952. $7.50.

Paper reviews experimental information on slip lines, preferably of metal single crystals, no attempt being made at interpretation. The investigations reported concern determination of slip direction and slip plane, the form of slip lines (straight or wavy, continuous or discontinuous), the spacing of lines, and the amount of slip per line. Slip direction is always line of closest atomic spac-

ing, but other features of slip vary with metal, temperature, stress, and manner of loading. Techniques include light and electron-microscope observations, multiple-beam interferometry, and, for transparent crystals, photoelasticity. Influence of magnification and resolving power is discussed. Recent and current studies of cross slip and deformation bands and the influence of surface treatment are reported.

From author's summary by A. Kochendörfer, Germany

868. **Conrad, C. M., and Ziifle, Hilda M., Implications of Philippoff flow curves for the determination of intrinsic viscosity of high polymer nitrocelluloses,** *J. Colloid Sci.* **7**, 3, 227–235, June 1952.

Paper deals with an analytical treatment of the consistency curves of cellulose nitrate in butyl acetate at different concentrations published by Philippoff and Hess. The consistency curves represent the relations between the consistency variables: $V = 4Q/\pi R^3$ (R radius of the capillary tube, Q quantity of flow per unit time), and $P = \tau_R = R\Delta p/2L$ (L length of the tube, Δp difference between inlet and outlet pressure).

By plotting the slopes $z = d$ (ln V)/d(ln P) of the logarithmic consistency curves vs. ln P or ln V, curves result which increase from the value 1, being valid for Newtonian fluids, to a maximum and then recede again nearly symmetrically to 1 at higher ln P and ln V, respectively. While the maxima of the z-curves vs. ln P shift with higher concentrations to higher values of ln P, the curves vs. ln V are much more unimodal, that is, the maxima lie nearly at the same value of ln V. In both plottings, the amplitude of the curves increases with increasing concentrations. If z is plotted against the concentration c, the curves at constant P and at constant V display a large variability of slope. The curves based on constant P are more variable than the curves at constant V. The same behavior appears if the reduced viscosity counterpart is plotted vs. C, although the variability of slope is not so large. Contrary to the experience of Krieble and Whitwell, the curves are straight lines only at special values of P and V. In most cases they are curvilinear. Plotting the reduced viscosity vs. c, it appears that the intrinsic viscosities that are the intercepts of these curves at zero concentration vary widely with the used value of V and P, respectively. This has been noted before for cuprammonium and cupriethylenediamine solvents.

Ulrich Rost, Germany

869. **Müller, F. H., Further experiments and considerations on cold distortion** (in German), *Kolloid Z.* **126**, 2/3, 65–72, May 1952.

Stress (σ)-strain (ϵ) diagrams of extending strips of polyvinylchloride resemble those obtained in mild-steel tensile tests. There exist (1) a Hookean region, ending in an upper yield point, (2) a constant stress (ideal plastic) region, and (3) a strain-hardening region which is linear. The yield stress is reduced with increasing temperature, disappearing at about 80 C. The second region is wider and strain hardening is "steeper" the lower the temperature. A series of curves for different temperatures look like pressure-volume isothermals. This suggests to author a generalization of Hooke's law in analogy to van der Waal's equation, namely $(\sigma + a\epsilon^2)(1/\epsilon - b) = R'T = E$. This reviewer misses records of strains after removal of stress at different levels, without which elastic and viscous response cannot be separated, a prerequisite for author's microstructural approach.

M. Reiner, Israel

870. **Skudrzyk, E., Internal friction and elastic properties of solid liquid and gaseous bodies. II** (in German), *Öst. Ing.-Arch.* 6, 3, 157–196, May 1952.

The author continues his studies of materials defined by superposition of all orders of local time derivatives of stress and strain components [*Acta Phys., Austr.* 2, 148, 1948; AMR **4**, Rev. 1485]. For infinitesimal oscillations of frequency ω, these equations are equivalent to those obtained by supposing the ordinary moduli of elasticity to be complex and frequency dependent [see Frenkel and Obrastzov, *J. Physics Acad. Sci. USSR* **2**, 131–142, 1940]. The author discusses the phenomena represented in this theory. Among these are simple and complex relaxation effects in solids and fluids, elastic aftereffects, viscous and plastic damping, hysteresis, and plastic flow. There are many comparisons with experimental data, which are used to determine experimental values for the various constants for various specific materials. A great deal of labor has gone into the work. C. Truesdell, USA

871. **Yamamoto, Y., Variational principles of equilibrium of an elasto-plastic body,** *Quart. appl. Math.* **10**, 3, 215–224, Oct. 1952.

Author claims to have established, under severely restrictive conditions, a complementary pair of variational principles pertaining to a finite process of distortion in a plastic-elastic body. Reviewer was unable to follow the argument.

Rodney Hill, England

872. **Read, W. T., Jr., and Shockley, W., On the geometry of dislocations,** "Imperfections in nearly perfect crystals," New York, John Wiley & Sons, Inc., 77–94, 1952. $7.50.

Plastic deformation of nearly perfect crystals is explicable in terms of movement of dislocations. Paper mentions various types of possible imperfections in nearly perfect crystals, and non-mathematically discusses dislocations in detail. Fundamental ideas of Burgers circuit, Burgers vector, virtual slip surface, distinction between slip and diffusive motion are described. A review is given of recently developed possible mechanisms for producing the avalanche of dislocations needed to form a slip band.

B. G. Rightmire, USA

Failure, Mechanics of Solid State

(See also Revs. 908, 914)

873. **Klöppel, K., Mechanics of materials and safety of welded steel structures** (in German), *Schweissen Schneiden* **3**, (S)81–(S)89, Nov. 1951.

Discussion of the notched-specimen test and its application in judging the suitability of steel for use in welded construction. Attention is given to the stress distribution in the standard DVMR specimen and its relationship to failure. Brittle failures receive considerable attention, particularly as they influence the method of failure and usefulness of test results.

Glenn Murphy, USA

874. **Kudryavtsev, I. V., Residual stresses as reserve of strength in machine design. (Vnutrenniye napryazheniya kak rezerv prochnosti v machinostroyenii),** Moscow, Mashgiz, 1951, 278 pp. $2.

Lack of satisfactory methods leads author toward development of a more general solution which could evaluate effect of residual stresses on strength and endurance of machine parts which are subjected to variable stresses.

Author states that the theoretical analysis of the effect of residual stresses on the fatigue strength of steel is based on three propositions: (1) Fatigue failure develops due to continuous-alternating slipping at the locations where grain is subjected to the largest stress; (2) value of the friction forces which act in slip planes varies with magnitude and sign of normal stresses in the

same planes; (3) magnitude of the friction forces which occur in the slip planes depends on composition and structure of the material.

From application of these principles, it can be observed for majority of metals that: (1) An amplitude of the limiting stresses of a cycle decreases as the mean tensile stress increases; (2) an amplitude of the limiting stresses of a cycle increases as the mean compressive stress increases. Superposition of residual stresses may cause (1) a change in the nominal values of tangential stresses in the slip planes, (2) a change in the normal stress components in the slip planes. Due to these changes in stresses, a variation in the effectiveness of the shearing stress may occur.

For a variable compound-stress state, the strength criteria are expressed by a relative value of the endurance limit. It is relative to the assigned unit value of the endurance limit for an axial stress state of the same variation.

Among the assumptions and steps employed by the author for the development of the proposed solution, the following two can be regarded as the most fundamental: (1) Belyaev's assumption which governs the effect of the normal stress component on the effectiveness of the tangential stress in the same plane; (2) an assumption that, for the same material, the limiting amplitude of the variation in the effective tangential stress remains invariant as the values of the mean stress of a cycle change.

Basic formulas are developed for a compound-stress state when the three principal normal stresses have a cophasal variation with respect to time, and follow a symmetrical cycle. Using analogous procedures, residual (constant) stresses are included. The ratio of strength criteria for combined (compound and residual) stress state with respect to strength criteria for compound-stress state only, will represent the effect of residual stress state alone.

Other cases of cophasal stress variations (with or without residual stresses) and nonsymmetrical cycles are treated in analogous manner. From results it can be observed that: (1) Residual stresses affect the endurance limit only when coefficient of "strength inequality" for residual stresses is not equal to zero. The effectiveness of residual stresses (with respect to fatigue strength) would increase as the coefficient of residual strength inequality increases. (2) An established residual-stress field (in the same material) can have various effects on the endurance limit, depending on the type of variable stress.

Author treats theoretically several particular cases when the above conditions do not apply. Although the basic assumptions and hypothesis appear to be sound, author points out that his theory should not be accepted as ideal for general use. Consideration of scale effect, stress gradient, and other factors can further improve the proposed theory.

Considerable part of the text is devoted to experimental studies made predominantly by author and his associates. Experimental data appear to agree with theoretical findings. Reviewer believes that the novelty of the subject and the simplicity of presentation will make this test of interest to designers and researchers in this field.

V. A. Valey, USA

875. Rinehart, J. S., and Pearson, J., Conical surfaces of fracture produced by asymmetrical impulsive loading, *J. appl. Phys.* **23**, 6, 685–687, June 1952.

Conical surfaces of fracture generated in thick-walled cylinders that were asymmetrically and impulsively loaded through the use of internal explosive charges are presented. It is deduced from qualitative considerations that the conical fractures result from the interaction between transient tensile stress waves. The two tensile stress waves that are responsible for the fracture arise from a single compressional stress wave that is reflected from two inclined free surfaces. The angle of fracture associated with these conical surfaces has been used to measure the velocity of propagation of the stress waves in low-carbon steel, brass, copper, lead, and 24S-T aluminum alloy.

From authors' summary by C. O. Dohrenwend, USA

876. Phillips, C. E., and Heywood, R. B., The size effect in fatigue of plain and notched steel specimens loaded under reversed direct stress, *Instn. mech. Engrs. appl. mech.* **165** (W.E.P. no. 65), 113–124, Proc. 1951.

Two steels were used in these tests, a 25-ton mild steel and a 65-ton $2^1/_2\%$ nickel-chromium steel. Both plain and notched specimens were used, the notch being produced by a transverse hole one-sixth the diameter of the specimen. As far as possible, geometrical similarity was preserved for a given series of specimens. Plain specimens having diameters ranging from 1.382 in. to 0.188 in. were tested. Results of this series showed that, with direct stress, there is no size effect in fatigue for the two steels tested. Geometrically similar notched specimens showed a size effect; the notch sensitivity of the smaller specimens being less. It is doubtful, however, whether the curves for stress and concentration factor should be extrapolated to unity (i.e., same fatigue strength as an unnotched specimen) at zero diameter of specimen.

Tests were also carried out in a rotating-beam machine, and the fatigue limit obtained in these tests was greater than that obtained under alternating tensile loading. A few tests were carried out with grooved specimens and shouldered specimens. Both types of specimens had a greatly reduced fatigue limit.

J. A. Pope, England

877. Russenberger, M., Contribution to the fatigue strength of notched bodies (in German), *Schweiz. Arch.* **18**, 7, 220–227, July 1952.

Author performed experiments relating the change of damping capacity of 0.40% C steel with repeated stressing. Both the "dynamic damping," which was measured at the stress-cycle frequency of 10,800 cpm, and "static damping," which must have taken at least several minutes to measure the hysteresis loop, were determined. At a stress slightly below the fatigue-endurance limit, both the static and dynamic damping had a low and constant value; at a stress slightly above the endurance limit they increased greatly after 6000 stress cycles. Although the cyclic stress was reduced to the lower value, the damping remained the same. After a rest period of twenty-four hours, the dynamic damping was at a lower value, but quickly returned to the high value. The static damping was not reduced by the rest and remained the same before and after subsequent stressing. The effects of cold-stretching and rest periods of 4000 hours were examined. The static damping returned to the low value for the unstressed material when heated to 200 C.

It is interesting that the stressing and rest periods could have different effects on the static and dynamic damping.

George H. Sines, USA

878. Moszyński, W., On the logarithmico-normal distributions of random variables and the possibility of their technical application (in Polish), *Wiadomości PKN* **20**, 4, 269–278, Apr. 1952.

Author assumes a logarithmico-normal distribution of random variables, i.e., such a distribution that the logarithms of the numerical values of a random variable, which naturally cannot be negative, are normally distributed. The logarithmico-normal distribution may have a wide application in technical sciences. The validity of this assumption has been proved with respect to ultimate strength and yield point on basis of testing about 800 specimens of different kinds of plain carbon steel. By determining the strength of different constructions, the most important

formula is $u = au_1^{\alpha_1}u_2^{\alpha_2}$. . ., where a is a positive constant, the exponents α_1, α_2. . . are constants, and u_1, u_2, . . . are mutually independent random variables. The random variable u is also logarithmico-normally distributed. The calculation that u does not exceed any given limit is as easy as in the case of a linear function of random variables having a normal distribution. This property of logarithmico-normal distribution can be utilized in calculating the safety factors of engineering and machine structures. Assuming the relative limit deviations corresponding to the probability $p = 0.98$ as standard, it is possible to establish 10 classes of safety, corresponding theoretically with the probability of not exceeding the allowable stress equal to 0.98, 0.99, 0.995, 0.998, . . . 0.99998. These values do not give, of course, a true picture of the safety of the structures because of the inevitable divergence between the theoretical and real distributions, especially at both ends of the range. However, these classes are convenient in applications because it is possible to ascribe various typical constructions to established classes of safety and, in this way, to estimate the safety factor, as shown by an example.

K. Zarankiewicz, Poland

879. **Moszyński, W., Determination of safety factors in strength calculations of engineering and machine constructions** (in Polish), ***Wiadomości PKN*** **20,** 8, 608–619, Aug. 1952.

Presenting the most general method of determining the safety factor in the strength calculations of a construction, author assumes the logarithmico-normal distribution of all the random variables entering into the calculation, and, based on the safety classes proposed by him (see preceding review), considers and numerically solves 8 different examples of calculating safety factors in typical cases of constant loads: A prismatic rod axially stretched, long and short compressed columns when there is danger of buckling, beams bent under their own weight and under external load—a cantilever beam and a simple beam, and a steel cable. Author divides the safety classes into three groups with respect to the importance of structural elements, i.e., to the danger which their damaging would create for the construction as a whole, and for the men employed on it or utilizing it. Each of those groups is subsequently divided into three subgroups with respect to the facility of repair. In this way, a convenient key is obtained for choosing adequate safety classes, serving as a basis for determining the safety factors. Finally, author gives proposals concerning the standardization of concepts connected with the above calculations and the numerical values of relative limit deviations and safety classes.

K. Zarankiewicz, Poland

Design Factors, Meaning of Material Tests

(See Revs. 878, 879)

Material Test Techniques

(See also Revs. 894, 899, 902, 914)

880. **Muster, D. F., and Volterra, E. G., Use of a rotating-drum camera for recording impact loading deformations,** *J. Soc. Mot. Pict. Telev. Engrs.* **59,** 44–48, July 1952.

The details of a rotating-drum camera are described. The camera is used to record displacement-time data for short cylindrical specimens made of a rubberlike material which are subjected to compressive impact loadings lasting from 5 to 20 milliseconds. The auxiliaries to the camera are discussed in light of the particular needs of a study being conducted on the dynamic properties of plastics and rubberlike materials.

From authors' summary

881. **Jones, R., A method of studying the formation of cracks in a material subjected to stress,** *Brit. J. appl. Phys.* **3,** 7, 229–232, July 1952.

A method is described to determine the onset of cracking in specimens of concrete subjected to tension or compression in mechanical testing machines. While the loads were being applied, measurements were made at intervals of the velocities of ultrasonic pulses passing through the test piece in the axial and/or transverse directions. In compression, the velocity of the ultrasonic pulses in the direction of loading remained constant while the load was increased to failure, but in the transverse direction a fall in the velocity started at only a fraction of the ultimate load, and the velocity then decreased with increase of load. This indicated that cracking occurred internally parallel to the direction of loading. The load at which it started depended on the strength of the concrete and the uniformity of the stress distribution. In tension, fracture was preceded by only a very small, and often insignificant, amount of cracking which occurred at right angles to the direction of loading.

From author's summary by Vincent P. Zimnoch, USA

882. **Rankin, A. W., Boyle, C. J., Moriarty, C. D., and Seguin, B. R., Thermal cracks in turbine and generator rotor forgings,** *Mech. Engng., N. Y.* **72,** 7, 559–566, July 1950.

Investigations described in this paper were initiated by an epidemic of thermal cracks in turbine and generator rotor forgings. Ultrasonic tests cannot distinguish between thermal cracks, which are harmful, and harmless nonmetallic conclusions. Both of these give a similar type of reflectoscope signal. Additional tests are necessary to determine the cause of the reflection.

Paper has four parts. The first is the general review of the results of ultrasonic tests on a large number of rotors; the second part deals with particular details, including the interpretation of the results; the third part gives results of metallurgical investigations; and the fourth part deals with the reduction of the bursting strength due to thermal cracks.

The ultrasonic inspection is performed with a crystal which is in continuous contact with the surface of the rotor while the rotor is being slowly rotated. The size of the reflection due to the crack is compared with the size of the reflection from the internal bore hole to determine the seriousness of the crack. Further identification is easily performed when the inclusion of the crack breaks through to the surface. A magnetic particle test can then be performed without additional work.

If there is no break through the surface, trepanning of the rotor is necessary before the character of the sonic discontinuity can be determined. The process of investigation is described in detail, including trepanning, magnetic particle testing, taking of photomicrographs, and making of tension specimens out of the core-drilled bore. Investigations of many rotors enabled the authors to tabulate characteristics of thermal cracks and of metallic conclusions.

To determine the effect of thermal cracks on the strength of the disk, spins on the rotor material have been conducted simulating operating conditions. It has been found that thermal cracks may cause reduction to 83% of the strength of the sound disk. Due to the use of a safety factor of more than two for the sound disk, there is still a considerable safety factor left for a disk with thermal cracks.

R. O. Fehr, USA

883. **Lösel, R., Nondestructive material testing with ultrasonics** (in German), *Feingerätetechnik* **1,** 4, 175–178, July 1952.

Author describes briefly four methods for utilizing ultrasonics in nondestructive materials testing. Much more extensive information on the subject is given by Mason. ["Piezoelectric crystals and their application to ultrasonics," chapt. XV.]

E. A. Ripperger, USA

884. Hart, H. T., Determination of the modulus of elasticity of steel wire cables (in Dutch), *Schip en Werf* **19**, 15, 318–322, July 1952.

Trial experiments, carried out with a Huggenberger extensometer on gage length of 0.5 m, showed that this method could not be applied to the thicker cables (diam almost 2 in.) which are used for stays and riggings of sea ships. A large scatter of test data was found, due to movements of the clamps caused by torsion of the cable. Measurements by means of a cathetometer, over a gage length of almost 1 m, also showed too much scatter, probably due to the relatively short gage length. The final measurements were made on lengths of 10 to 18 m, and gave reproducible results. It is shown that the modulus of elasticity for steel wire cables, containing not more than one core of hemp, amounts to approximately 1.2×10^6 kg/cm.²

J. H. van der Veen, Holland

885. Hastings, C. H., Choosing equipment for nondestructive testing, *Trans. Amer. Foundrymen Soc.* **59,** 309–314, 1951.

The article is written to guide a foundry operator in his selection of nondestructive test equipment. It considers four test methods as most practical for production foundries; two of these methods, involving radiography (x-ray, radium, radioactive isotopes) and magnetic-particle (magnaflux) methods of test, are given principal attention. Tests involving penetrating oils and tests involving ultrasonic techniques are also discussed. No new methods and no bibliography are given.

I. Vigness, USA

886. Weck, R., Fatigue strength of panels with welded angle stiffeners, *Welding J.* **31,** 7, 338s–349s, July 1952.

The investigation was to determine the relative lives of different types of welded joints in stiffeners attached to plating. The plates were mild steel to British Standard 13. All specimens were tested as free-free beams in bending by resonant vibration. Because of the transverse bending of the plating in addition to the longitudinal bending, the stresses in the plating were biaxial, as would be the case of the plating of a ship's hull. Fifteen types of specimens covered variations in attachment welds between the plating and stiffeners and in the transverse welds and reinforcing plates on the stiffeners. A few riveted specimens were tested, and one with open holes in the stiffener. The fatigue failure could in no case be related to the radiographic findings pertaining to that specimen. Intermittent staggered welds were markedly superior to intermittent chain welds. Welded joints in stiffeners generally decrease the fatigue strength in comparison with that of unjointed stiffeners. For good butt welds, the decrease is not as great as that caused by drilled holes in unjointed stiffeners.

Marshall Holt, USA

Mechanical Properties of Specific Materials

(See also Revs. 778, 810, 822, 823, 837, 839, 861, 862, 863, 865, 867, 868, 869, 872, 876, 880, 881, 921, 1117, 1118)

887. Kostron, H., Mathematics of the tension test (in German), *Arch. Eisenhüttenw.* **22,** 9/10, 317–324, Sept./Oct. 1951.

With knowledge of the work of P. Ludwick and G. Sachs, author attempts to present a simple process by which the dimensions of a tensile specimen of metal subjected to test may be clearly connected to other physical properties of the material. It is clear that the physical meaning of tensile strength and rupture stress is difficult to express. Author presents a simple equation relating stress, deformation, a measure of resistance to deformation, and a slope coefficient.

Reviewer agrees with author in his observation that the tendency of materials to yield more or yield less than calculated values should be further investigated. Paper suggests limited research possibilities in this area of materials testing and interpretation of the results.

W. T. Daniels, USA

888. Servi, I. S., Norton, J. T., and Grant, N. J., Some observations of subgrain formation during creep in high purity aluminium, *J. Metals* **4,** 9, 965–971, Sept. 1952.

Creep tests were carried out on high purity aluminum from 400 to 1200 F. Metallographic and x-ray examination revealed subgrains which were larger, the smaller the creep stress. The average size of the subgrains approaches the value predicted by Orowan for the minimum slip-band spacing. From these results, authors conclude that slip is the primary mechanism for deformation at elevated temperatures and not the formation of subgrains. Subgrains are considered to be formed by polygonization. Twenty references are given.

M. A. Meyer, South Africa

889. Carter, J. J., Mends, D. N., and McKeown, J., The creep and fatigue properties of two commercial aluminum bronzes at 500° C, *Metallurgia, Manchr.* **45,** 272, 273–281, June 1952.

Data are presented on the creep and fatigue properties of two aluminum bronze alloys at 500 C. The recrystallization, precipitation at the grain boundaries, and other metallurgical changes which occurred during the tests are discussed. For tests up to a few thousand hours' duration, the creep and fatigue properties of the cold-worked materials are superior to those of the annealed materials. However, for longer duration tests, the cold-worked materials tend to revert to the annealed condition and thus tend to lose their superiority. Different batches of the same material displayed significantly different creep properties, which could be partially associated with differences in grain size. The rotating-beam fatigue properties at 500 C were, however, approximately the same for the two materials in the same state. However, the annealed material displayed significantly lower but more consistent fatigue properties than did the cold-worked material. One feature of the fatigue data is that the endurance curves still fall noticeably beyond 50×10^6 cycles, a condition which was associated by the authors to the corrosion-fatigue effects. When exposed to temperature and either no stress or steady stress, the scale formed was always thin and strongly adherent for times as long as 2000 hr, whereas under cyclic stress the scale was exfoliative after times as short as 50 hr.

B. J. Lazan, USA

890. Sherby, O. D., and Dorn, J. E., Creep correlations in alpha solid solutions of aluminum, *J. Metals* **4,** 9, 959–964, Sept. 1952.

By correlating the Zener-Holloman functional equation $\sigma = \alpha(\dot{\epsilon}e^{\Delta H/RT})$ with subject material, following conclusions are reached: (1) Creep and tensile data can be simply related by this equation above 400 K, where ΔH has a single value for all alloys investigated. Below 400 K, use of this parameter appears inadequate. (2) Creep strains for a given stress plotted in terms of a temperature-compensated time $\theta = te^{-\Delta H/RT}$ yielded a single creep curve. This suggests a method for extrapolation of short-time creep data.

George Gerard, USA

891. Bumps, E. S., Strain patterns in Charpy impact specimens of 0.20 pct C mild steel, *J. Metals* **4,** 10, 1067–1070, Oct. 1952.

A series of macrographs are presented for the purpose of graphically recording the strain phenomenon that accompanies the energy transition in the Charpy-impact testing of a mild steel that is susceptible to strain-aging.

From author's summary

892. **Wellinger, K., and Gimmel, P., Bending fatigue of nitrited test bars with various diameters** (in German), *Arch. Eisenhüttenw.* **23,** 5/6, 203–205, May/June 1952.

Failure of nitrided or otherwise surface-hardened rotary bending-fatigue test specimens frequently starts from a point below the surface so that surface finish is without effect on fatigue strength. Fatigue tests with nitrided 0.34% C, 1.4% Cr, 1.1% Al steel of 70 kg/mm² tensile strength, with surface hardness increased to 1050 HV from 190 HB of core, showed bending-fatigue strength of core ±34 kg/mm² independent of test-piece diameter, with surface fatigue strength decreasing from ±45 kg/mm² for 5-mm diam test pieces to ±41 kg/mm² for 6.5-mm diam test pieces, to 40 kg/mm² for 8-mm diam test pieces. Conclusion is drawn that for test pieces of diameter greater than 20 mm, nitrided layer has no effect on 1×10^6 cycle bending-fatigue strength which will fall to that of the core material. For stresses producing failure at less than 10^6 cycles, fracture always starts from surface, even in test pieces of small diameter, which may explain why fatigue failure starting below surface has never been observed in service failures of nitrided components. Authors surmise that service failures are caused by short bursts of accidental overloads producing stresses above 1×10^6 cycle limit.

Reviewer thinks value of investigation would have been greatly enhanced by including series of tests on non-nitrited test pieces in order to determine whether effect observed is size effect or definitely attributable to nitrided layer, and by extending range of diameters well beyond 8 mm, say to 25 mm.

R. Weck, England

893. **Appaly, C., and Bollenrath, F., Tension fatigue strength of unwelded and welded steel specimens with and without corrosion influence** (in German), *Brennstoff-Wärme-Kraft* **4,** 7, 223–227, July 1952.

Tension-fatigue tests were done with two heat-treated steels of 3-mm thickness. Steel A contained 0.18 C, 0.4 Si, 2.0 Mn; steel B, 0.29 C, 0.3 Si, 1.1 Mn, 0.7 Cr, 0.1 V. Tensile strengths were 61 and 70 kg/mm², respectively. Arc-welded bars were compared with unwelded bars, the unwelded bars always having polished surfaces. Some of the welded bars were given polished surfaces (after machining the welds) and others were left as-welded, with mill-scale, and non-machined welds. All tests were done with and without corrosion influence of tap water. The fatigue limits (10^7 cycles) of the polished welded bars were found to be 40% lower than those of the unwelded bars (for both steels). The as-welded bars were still worse. For steel A, a 55%, and for steel B a 70%, lower fatigue limit was found than in the unwelded condition. Obviously, steel B was more sensitive to the notch effect of the rough weld surface than steel A. For the tests with corrosion influence of tap water, fatigue limits could not be determined, the Wöhler-curves still having an appreciable slope at 10^7 cycles. The corrosion influence was found to be rather large. The stress to rupture at 10^7 cycles for the unwelded bars of steel A was only 15 kg/mm² with corrosion influence, whereas the stress to rupture (fatigue limit) without corrosion amounted to 45 kg/mm².

J. H. van der Veen, Holland

894. **Kloot, N. H., A micro-testing technique for wood,** *Austral. J. appl. Sci.* **3,** 2, 125–143, June 1952.

Paper describes a device for testing thin, longitudinal sections of wood in tension parallel to the grain, which may be used for studies relating to the influence of silvicultural practices on certain physical and mechanical properties of wood. The utility of the device is illustrated by a description of exploratory work in which serial tangential sections 80 microns thick of blocks taken from standing trees of different species and rates of growth are compared, showing radial patterns of strength variation. Patterns of correlation of tensile strength and density are also shown. Radial patterns of tensile-strength variation of two trees of the same species from the same site, but differing appreciably in rate of growth, are compared to illustrate a possible application of this method to the evaluations of the effects of various silvicultural treatments or growth conditions on the properties of wood. The method is adapted to sampling standing trees, making possible continuous studies of wood as it grows. Results of the tests are comparative and cannot be translated directly to properties of timbers of practical size.

S. B. Preston, USA

895. **Pearson, R. G., Variability of timber and the derivation of design stresses,** *Austral. J. appl. Sci.* **3,** 2, 144–155, June 1952.

Two methods are discussed of allowing for the variability of clear timber in deriving design stresses. It is shown that reducing the mean by a fixed percentage is unsatisfactory, and that a more rational method is to use a particular probability point of the frequency distribution.

The allocation of a common stress to groups of species is complicated by differences in variability of the species. Grouping according to means is shown to be generally very conservative. Use of a particular probability point is a more satisfactory basis for grouping, but it requires more precise information about the species and, hence, larger samples for testing.

H. F. Marco, USA

896. **Kühne, H., and Strässler, H., On the determination of moisture content of wood** (in German), *Schweiz. Arch.* **18,** 8, 264–275, Aug. 1952.

A survey is made of the four principal methods for determination of moisture content of wood. Consideration is given to their accuracy, efficiency, and effectiveness. The four methods described are the oven-dry, air-hygrometric, electric-resistance, and dielectric-loss methods, with the oven-dry method being the most accurate one.

Test data by the authors present information on the accuracy and sensitivity of the various instruments available. Factors influencing the accuracy of the readings are discussed. A 48-item bibliography is appended.

E. G. Stern, USA

897. **Sherman, M. A., and Axilrod, B. M., Stress and strain at onset of crazing of polymethyl methacrylate at various temperatures,** *NACA TN* 2778, 21 pp., Sept. 1952.

The materials tested at 23 C, 50 C, and 70 C were commercial cast polymethyl-methacrylate sheets of both general-purpose and heat-resistant grades. The results indicate that a "critical-strain theory" for the threshold of crazing, as has been suggested for polystyrene by Maxwell and Rahm, is not applicable to polymethyl methacrylate. The strain at the threshold of crazing tended to decrease with increase in temperature from 23 to 50 C. Between 50 and 70 C, no consistent trend for the strain at crazing was detected. The stress at the threshold of crazing was about 80 to 95% of the tensile strength at all temperatures.

From authors' summary

898. **Boller, K. H., Fatigue tests of glass-fabric-base laminates subjected to axial loading,** *Forest Prod. Lab. Rep., U. S. Dept. Agric.* no. 1823, 12 pp., 10 tables, 35 figs., May 1952.

Comprehensive fatigue data on several glass-fabric-base laminates subjected to axial load are presented. Laminates and resins met minimum requirements of USAF specifications numbers 12051 and 12049, respectively. Variables investigated were warp direction, notch, moisture, mean stress, and fan cooling. Number of cycles ranged from 1 thousand to 10 million.

Fatigue strength (10 million cycles) was found to be approximately 25% of static tensile strength regardless of moisture or cooling. Notch reduced strength an additional 5%. Moisture reduced fatigue strength at 10 thousand cycles considerably. S-N curve for specimens cut 45° to warp leveled off at approximately 40 thousand cycles, while specimens 0° to warp showed no definite limit.

Reviewer finds this to be one of most nearly complete investigations of its kind. F. J. Mehringer, USA

899. Fletcher, W. P., and Gent, A. N., Apparatus for the measurement of the dynamic shear modulus and hysteresis of rubber at low frequencies, *J. sci. Instrum.* **29**, 6, 186–188, June 1952.

An apparatus is described which subjects a rubber test piece to a force in simple shear, varying sinusoidally with time in the frequency range 0.0017–17 cps; the instantaneous values of force and displacement are measured by photoelectric pickups. From the display on the screen of a cathode-ray tube of the mechanical hysteresis loop described by the vibrating rubber, measurements are made which allow calculation of the dynamic shear modulus and hysteresis. Typical results are given.

From authors' summary

900. Davies, D. M., The effect of frequency on the behaviour of rubber under cyclical deformation, *Brit. J. appl. Phys.* **3**, 9, 285–288, Sept. 1952.

Apparatus records autographic hysteresis loops for cyclic deformation of rubbers in compression. Dynamic compression is superimposed on constant static compression. Temperature is not controlled nor specified. Results on a rubber (presumably natural?) loaded with 60% carbon black show dependence of stiffness (force per unit deformation) and resilience on frequency and amplitude. Exact values of modulus are not calculated. With increasing frequency from 0.1 to 900 cpm, stiffness increases 20 to 60% depending on amplitude, and resilience decreases about 5%. With increasing amplitude from 3 to 11% of the undeformed thickness, stiffness and resilience (at 10 cpm) decrease about 20 and 10%, respectively. Frequency dependence of stiffness can be analyzed by mechanical model of two springs and one dashpot, but only by making dashpot viscosity itself frequency-dependent. Reviewer believes experiments are of value for practical data at low frequencies and high amplitudes; but for theoretical analysis data, should be combined with data at small amplitudes and covering wider frequency range.

John D. Ferry, USA

901. Polmanteer, K. E., Servais, P. C., and Konkle, G. M., Low temperature behavior of silicone and organic rubbers, *Indust. Engng. Chem.* **44**, 7, 1576–1581, July 1952.

Modulus, torsional stiffness, and per cent recovery data all demonstrate the superior low-temperature characteristics of two types of silicone rubber, as compared with natural rubber and GR-S. Type II, extreme low-temperature silicone rubber, as represented by Silastic 250 and the Silastic 6000 series stocks, did not show appreciable stiffening until some temperature between −112 and −130 F, was reached. Both the natural rubber and GR-S were stiff at −76 F, as would be expected from brittle point and second-order transition measurements.

It is shown that silicone rubber type II demonstrates both a supercooling effect and very rapid crystallization. Reasons for the good low-temperature characteristics of silicone rubber are given in a theoretical discussion. A special short-term aging technique for silicone rubber is suggested as a substitute for long-term aging. A low-temperature modulus apparatus is described.

From authors' summary

902. Schiltknecht, E., Hardness testing of rubber with special consideration of very soft rubber types, such as creep rubber and sponge rubber (in German), *Schweiz. Arch.* 18, 7, 227–233, July 1952.

Paper describes two conventional hardness testers (that of Shore, which is accepted by the ASTM, and the DIN-type). Then it discusses two new types. One measures the pressure necessary to reduce the thickness of a material to half its initial value; the other indicates the depth of penetration of a plunger acting under a given pressure. B. Gross, Brazil

903. Gent, A. N., and Rivlin, R. S., Experiments on the mechanics of rubber. II: The torsion, inflation and extension of a tube, *Proc. phys. Soc. Lond.* (*B*) **65**, part 7, 391B, 487–501, July 1952.

The first part of this two-part paper reports on an indirect experimental verification of the forces necessary to produce simple extension, radial inflation, and torsion in a tube of incompressible and highly elastic material. The case studied is that in which the amount of torsion is small, and vulcanized natural rubber was used as the experimental medium. The agreement between theory and experiment was reasonably good.

The second part consists of a study of the reason for the departure of the measured values of the derivatives of the stored energy function W from the values given by the kinetic theory of rubber-like elasticity. Experimental studies on the effect of different states of vulcanization on the properties of rubber vulcanizates, and of the effect of the swelling action of solvents on the volume of the vulcanizates, lead authors to think that cross linkages between molecular chains are responsible for the discrepancies between the observed and ideal values of the stored-energy function. The authors further speculate that these cross linkages would have to possess the following properties: (1) They can be broken by deformation of the rubber and, presumably, can reform in the deformed state in such positions as to relax part of the free energy of deformation of the macromolecular network; (2) they can be broken by swelling the rubber; (3) hysteresis in rubber is associated with their breaking or re-formation, and a relatively large number of molecules are involved in such a mechanism.

Yoh-Han Pao, USA

904. Olerup, H., Calculation of the variance-length curve for an ideal sliver, *J. Text. Inst. Proc.* **43**, 6, P290–P293, June 1952.

Assuming that the only source of correlation in a sliver lies in the common fibers at two adjacent points, author, referring to "the principle of common elements," concludes that the coefficient of correlation consists in the cross section of common fibers. Hence, for sections whose distance x is smaller than the maximum length A of the fibers, the correlation coefficient rx is given by the distribution function of the tuft diagram.

Introducing this function in Cox and Townsend's equation, author calculates successively the variance-length curve for lengths smaller than the mean length of the tuft diagram [$r(x)$, in that case, is assumed a linear function of x] and for lengths greater than A. These expressions are transformed by introducing the squares of the coefficients of variation of the three fiber diagrams. The variance-length relation found in that way is plotted in a logarithmic scale; for lengths sufficiently great, it becomes a straight line. D. De Meulemeester, Belgium

905. Kuhlenkamp, A., New measuring devices for textile machines (in German), *Feinwerktech.* **56**, 4, 92–97, Apr. 1952.

Paper describes theoretical and design principles of a new apparatus for measuring of stretching or elongation of a fabric

when it passes through a machine, e.g., a finishing machine; it also describes a new apparatus for continuous measurement of the viscosity of a liquid, e.g., smoothing liquid.

From author's summary

906. **Moore, A. C., and Tabor, D., Some mechanical and adhesive properties of indium,** *Brit. J. appl. Phys.* **3**, 9, 299–301, Sept. 1952.

Experiments are described showing that (in the absence of surface contamination) the adhesion between indium and metal surfaces depends only on the area of contact and on the time of breaking. The detailed behavior may be correlated with the creep properties of indium. With nonmetals such as diamond, glass, thick metal oxides, and certain plastics, very strong adhesions to indium are observed, while with polytetrafluoroethylene, which has a very low coefficient of friction, the adhesion is negligibly small. (These results suggest that in the sliding of nonmetals, adhesion at the interface plays a part in the frictional mechanism analogous to the cold-welding process in the friction of metals.)

From authors' summary

907. **Bush, S. H., A statistical analysis of the mechanical properties of cast and wrought gold dental alloys,** *ASTM Bull.* no. 185, 46–50, Oct. 1952.

Linear correlations were found for proportional limit and tensile strength, proportional limit and Brinell hardness number, and tensile strength and Brinell hardness number. These correlations are given in graphical form, together with the 5% limits of error.

The most satisfactory relationship was found to be for proportional limit and tensile strength. A pronounced scatter was noted when Brinell hardness number was considered. It is felt that control of such factors as heat treatment and the method of conducting the mechanical tests would reduce the scatter to a marked degree. This is supported by the experimental results.

From author's summary

908. **Louis, H., Brittle failure observed in bridge structures** (in French), *Rev. Soudure* **6**, 2, 96–110, 1950.

Fourteen cases of brittle fracture in details of welded bridges are described and illustrated. Designers of welded bridges and of other welded out-of-doors steel structures ignore this document at their peril. It is a veritable Chamber of Horrors, exhibiting the joint effect of bad detail design, high residual stresses, notch brittle steel, and low service temperature. The only shortcoming is in the description of material. More detailed information on mechanical properties, chemical composition, and grain size of materials involved would be desirable. All bridge engineers must be indebted to author for making this important information publicly available for the first time.

R. Weck, England

909. **Druyvesteyn, M. J., and Meyer, M. A., The hardness of metals** (in Dutch), *Metalen* **7**, 12, 13; 203–206, 219–222; June, July 1952.

Based on E. Meyer's formula load $P = ba^n/r^{n-2}$ (b and n constants, a radius impr., r rad. ball), relation for Rockwell B hardness $H_B = 130 - 250\,(P_g^{2/n} - P_k^{2/n})/(r^{4/n} - b^{2/n})$ (P_g is main, P_k initial load) is derived. Accepting Thabor's concepts that mean pressure in ball impression equals $2.8 \times$ yield stress σ at $0.20 \times a/r$ (conventional) strain e in tensile test and in Vickers impression $3.2 \times \sigma$ at 0.08 strain, Rockwell ball, as well as Meyer, Brinell, and Vickers hardness can be derived from stress-strain curve in tension. Applying Crussard's tension formula $\sigma = g(e)^{1/2}$ (g constant) and Thabor's concept, authors calculate for Vickers hardness ratio at 80 and 0% deformation 3.3, and suggest reasonable agreement with experiments in which deformation was obtained by rolling.

In reviewer's opinion, calculation lacks not only sound theoretical basis, but results are also too unreliable for practical use. Taking e as convention strain (Thabor's concepts refer to that), Crussard's formula leads to constant uniform strain e_m at maximum load in tension of 100%, while for e as true strain, e_m is 50%, both cases proving fundamental incorrectness of formula at once. Worse agreement with experiment will follow if it is taken into account that rolling strain corresponds to higher tensile strain for equivalent strain hardening.

Authors further discuss factors determining hardness of homogeneous and heterogeneous alloys. Hardness maximum in chill-cast eutectic alloys is explained by assuming low precipitation rate from supersaturated eutectic solid phases on absence of primary phases. Reviewer believes that retarded precipitation may be due mainly to strong tendency of eutectic liquids to supercooling, i.e., to lowered temperature at which subsequent precipitation in solid phases can start.

J. H. Palm, Holland

910. **Norris, C. B., Effect of unbonded joints in an aluminum honeycomb-core material for sandwich constructions,** *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1835, 8 pp., 4 tables, 1 fig., May 1952.

Static shear, fatigue shear, and compression tests were made on aluminum honeycomb-core material. Bending and compression tests were made on sandwich panels having this core material and aluminum facings. The bonds between the honeycomb cells of some of the core material were completely removed. The modulus of rigidity and the shear strength of the unbonded material were found to be about 70% of those of the well-bonded material. Calculated values, taking into consideration the stress concentrations in the neighborhood of the unbonded joints, lead to substantially the same value. Results of shear-fatigue tests of the core material are substantially consistent with the shear-strength values obtained from the static shear tests. The compressive strength of the unbonded material is about 50% of that of the well-bonded material, which is consistent with the assumption that the compressive strength is proportional to the critical compression stress of the cell walls.

From author's summary

911. **Dreyfus, L. A., High frequency heating and temperature distribution in surface hardening of steel,** *Proc. roy. Swed. Acad. Engng. Sci.* no. 208, 115 pp., 1952.

In surface hardening by high-frequency heating, two theoretical problems are encountered. First, is to calculate penetration of the eddy currents and the corresponding rate of generation of heat at various depths below the surface. Second, is to calculate the conduction of this heat into the bulk of the material, both during heating period and during subsequent quenching. If material is steel, which has a high field-dependent magnetic permeability, theory of the eddy currents takes an unusual form. Ferromagnetism disappears at the Curie temperature, and problems of current distribution and temperature distribution are interdependent. Author determines ranges of variables (frequency, power, specimen thickness) in which various approximations are valid, estimating errors in each case. Heats of transformation are neglected. Detailed numerical results are given.

F. R. N. Nabarro, England

912. **Thielsch, H., Copper in stainless steels,** *Welding Res. Counc. Bull. Ser.* no. 9, 31 pp., Aug. 1951. $1.

Physical, metallurgical, and welding properties of copper-bearing stainless steels containing up to 30% chromium and be-

tween 0 and 35% nickel, phase relations, hot-working properties, corrosion resistance, age-hardening characteristics, effects of Mn, Si, Mo, Cb, Ti, W, Be, V, etc., are described. Detailed tables listing the various patented and commercial alloys are also included.

From author's summary

913. Stambaugh, R. B., Electrical analog method for studying elastomer behavior, *Indust. Engng. Chem.* **44**, 7, 1590–1594, July 1952.

The complex behavior of elastomers can be reproduced by mechanical models. They are helpful for determination of complete set of characteristic curves of material under test, because their differential equation can be set up and solved without any difficulty in principle. It would be still more convenient to actually build the models and submit them to various types of forcing. This, however, meets with mechanical difficulties; but the analogy between mechanical and electrical quantities shows that for any mechanical model there exists an equivalent electrical one. This latter can be built easily and tested under any desired conditions, response curves being displayed on a cathode-ray oscillograph. Results are translated back into mechanical language by replacing voltage by force and charge by deflection. Present paper discusses methods of computation, describes complete equipment for setting up and testing electrical models, and shows some representative curves obtained with it. Nonlinear models are also considered.

B. Gross, Brazil

914. Lundborg, N., and Johansson, C. H., Experimental determination of the speed of propagation of cracks in glass as a function of the stress, *Ark. Fysik* **4**, 39, 555–558, 1952.

According to investigations by Schardin and Struth [*Glastechn. Ber.* **16**, 219–227, 1938; **23**, 1–10, 67–79, 325–336], Smekal [ibid. **23**, p. 186, 1950], and others, the speed of propagation of cracks in glass is a constant with a value of 1500 to 1600 m/sec. Edgerton and Barstow [*J. Amer. ceram. Soc.* **24**, 131–137, 1941] observed lower values as well.

The present investigation shows that the speed of propagation depends on the magnitude of the stress. The afore-mentioned constant represents an upper limiting value to which the speed of propagation tends as the static stress increases.

From authors' summary

915. Geil, G. W., and Carwile, N. L., Tensile properties of copper, nickel, and some copper-nickel alloys at low temperatures, "Mechanical properties of metals at low temperatures," *Nat. Bur. Stands. Circ.* 520, 67–96, May 1952.

Tensile tests were made at −196, −140, −78, −30, +25, and 100 C on high-conductivity copper, cupronickel, 70%-nickel, 30%-copper alloy, and nickel—all in the annealed condition. The data are presented in the form of true stress-strain curves determined from simultaneous load and diameter measurements. Several empirical-graphical methods for evaluating "work hardening" are discussed, and it is concluded that the rate of work hardening can best be measured by the slope of the true stress-strain curve. The rate of work hardening was approximately an hyperbolic function of the true strain, decreasing rapidly between zero and 0.5 true strain, with smaller decreases between 0.5 strain and fracture. The rate of work hardening decreased with increasing temperature.

In general, all of the materials showed increasing maximum and fracture stress as well as nominal ultimate stress with decreasing temperature. The true strain at fracture, however, did not vary greatly with temperature. This is in sharp contrast to other data obtained on ingot iron. True strain at maximum load increased with decreasing temperature, indicating greater uniform deformation at the lower temperatures. Nonuniform deformation, however, usually decreased with decreasing temperature.

R. H. Carey, USA

916. Jensen, J. W., A torsion pendulum of improved design for measuring damping capacity, *Rev. sci. Instrum.* **23**, 8, 397–401, Aug. 1952.

The construction of a torsion pendulum with an improved method of alignment and minimized friction losses is described. An optical recording system is employed, using a moving film camera with film velocity variable from 1 in. per hr to 60 in. per sec to record amplitude decay of freely vibrating specimens. Simplicity of operation permits semiskilled personnel to obtain 6 to 10 records per hr of high-damping Mn-Cu specimens. Sample records demonstrate how variations from 0.002% to over 33% in damping capacity may be measured at torsional stresses ranging from several hundred to about 20,000 psi.

From author's summary

917. Schwier, F., Contribution to the problem of mechanical aging in hard-drawn, patented steel wires (in German), *Stahl u. Eisen* **72**, 2, 58–66, Jan. 1952.

Author is concerned primarily with the mechanical property changes that come about through aging and, in particular, through mechanical or strain aging. Specifically, the influence of temperature and time, and especially the latter, on mechanical aging is investigated through a multitude of tests with drawn wires of different carbon content (0.4 to 0.8%) and size. Resultant curves show properties, such as tensile strength, various offset yield stresses, etc., as a function of annealing time under a constant annealing temperature. Annealing temperatures were varied from 70 to 420 C to get a picture of the temperature influence in artificial aging (aging under raised temperatures). Room temperature tests (natural aging) were included. Important are the rapid aging effects brought out, i.e., severe property changes after very short anneals. For instance, a three-minute anneal at 220 C increases the 0.01 offset yield stress of 0.79-C steel wire from 70 to 150 kg/mm². Increasing the annealing temperature from 170 to 220 C changed the increase in this same property of the same steel wire, due to aging, from 90 to 130%.

The latter part of the paper is focused on rapid aging in order to determine to what extent the ordinary wire-drawing process, which produces high temperatures in the wire through plastic flow and friction effects, reaches into this region of aging. Drawing tests are run with and without die cooling, in which measurements of temperature at the die are made (in previous works estimated). In these tests, type of steel, cross-sectional area reduction, lubricant, and velocity of drawing are varied. Temperatures as high as 185 C were recorded. Through these tests it is established that under usual wire-drawing conditions, the associated material temperatures must be reckoned with, since it is clear that they are situated in the rapid aging region. It is pointed out that, if aging phenomena are to be avoided, the question of adequate heat flow is important. The use made of the wire depends upon the mechanical aging involved, which can be intentionally used (example: spring wire requires high elastic limit) or removed by annealing subsequent to drawing.

The Introduction contains a review of the literature and the most accepted physical explanation of the aging process.

J. Miklowitz, USA

918. Crookston, J. A., and Torgeson, D. R., Long-time load tests on commercial classes of fire-clay brick, *J. Amer. ceram. Soc.* **35**, 10, 265–271, Oct. 1952.

The load-bearing characteristics of commercial super-duty,

high-duty, and siliceous fire-clay classes of refractories are studied and the results discussed in terms of optimum testing methods and possible service applications. Standard 9-in. straights were tested, using an electrically heated (Globar) furnace designed to permit simultaneous testing of two bricks placed on end. The bricks were subjected to a load of 25 psi, and the continuous vertical linear change was measured with revolving-drum kymographs. The bricks were tested under the following conditions: (a) 1½-hr hold at 2460 F; (b) 24-hr hold at 2400 F; (c) 100-hr hold at 2200, 2400, and 2500 F; and (d) 500-hr hold at 2200 F.

From authors' summary

Mechanics of Forming and Cutting

(See also Revs. 858, 882, 917)

919. **Robert, J. J., How to machine stainless steel with carbides,** *Amer. Mach.* **96**, 22, 109–112, Oct. 1952.

Data on tool angles, carbide grades, speeds, and feeds are drawn from successful applications on a broad range of stainless jobs.

From author's summary

920. **Pleteneva, N. A., and Rebinder, P. A., Effect of the surface active liquid medium on cutting processes and machinability of metals** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* 62, 4, 501–504, 1948.

Authors showed that, at high values of initial specific work of metal cutting (drilling) in a nonpolar medium, additions of surface-active substances to vaseline oil or kerosene, fully purified from polar additions, lower substantially the specific cutting work. Thus, addition of 0.25 to 0.5% of cetyl alcohol to kerosene lowers the specific work of aluminum drilling from $26.5 \cdot 10^{10}$ to $4.5 - 3.7 \cdot 10^{10}$ erg/cm³, or 6 times.

Investigation of the kinetics of drilling and of the dependence of the specific work on the pressure on the drill or—for a spear-shaped drill, used in the experiments—on the depth of drilling has shown that there exist two different regions of influence of surface-active lubricant components on the deformation of the metal. In the region of effective cutting, for the spear-shaped drill, in small depths, i.e., high specific pressures, an effect of adsorptional easing of deformations is generated which corresponds to a substantial lowering of the specific cutting work, when surface-active additions are made to the inactive (nonpolar) lubricant. As the spear-shaped drill deepens, the specific pressure diminishes, and the addition of the surface-active substance eases the slipping of the tool at much smaller pressures. Here the addition diminishes only the wear of the tool.

The dependence of the specific work on the concentration of the active substance has a distinctly adsorptive character (tests were made with propyl alcohol (C_3H_7OH), heptyl alcohol ($C_7H_{15}OH$), and cetyl alcohol ($C_{16}H_{33}OH$)), the specific work diminishing in the region of small concentrations, and reaching the limit in the region corresponding to the saturation of the adsorptive monomolecular layer.

By introducing into nonpolar kerosene the optimal addition, the surface of the metal becomes much smoother and brighter.

D. Mazkevich, USA

921. **Pleteneva, N. A., Shreĭner, L. A., and Rebinder, P. A., Hardening of aluminum at cutting in an inactive and in a surface-active medium** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* 62, 5, 653–655, 1948.

In connection with studies of metal cutting (see preceding review), authors now determine the microhardness H_μ of the metal surface (aluminum). Experiments showed: for aluminum with initial $H_\mu = 24$ kg/mm², at the bottom of the hole drilled in an inactive medium (nonpolar kerosene), values of $H_\mu = 115$ kg/mm² and higher are reached; in kerosene, with addition of active substance of optimal concentration, $H_\mu = 57$–65 kg/mm². The hardening in these cases is $\Delta H_\mu = 35$ kg/mm² against $\Delta H_\mu = 91$ kg/mm² in nonpolar kerosene. The values of H_μ are average values from a large number of measurements.

The dependence of hardening on the concentration of the active substance was studied by drilling aluminum in pure toluene and in solutions of stearic acid in toluene of various concentrations. The drawn curves show that, as the concentration grows, the efficiency increases, while the microhardness diminishes and, consequently, the hardening at cutting.

The curves, total specific work vs. depth of drilling, show that, while for drilling in nonpolarized medium the specific work increases sharply with depth, for drilling in an active medium the specific work increases but slightly. The influence on microhardness with depth for aluminum, mentioned above, is seen from the following table.

Depth in mm	H_μ at drilling in nonpolar kerosene	H_μ at drilling in kerosene + 0.25% palmitic acid
1	91	64
2.5	106	64
4.0	115	57

D. Mazkevich, USA

922. **Epifanov, G. I., and Rebinder, P. A., On the energy balance for the metal cutting process** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **64**, 4, 653–656, 1949.

Authors want to determine that part of the cutting work which is absorbed by the plastically deformed chip, and to find the effect on it of surface-active media. The investigation was done on a specially equipped drill. The way the temperature was measured and the formula for calculating the heat quantity are given.

Tests have been made on annealed samples of technical aluminum. As active lubricants, solutions of heptyl and cetyl alcohol, caprylic and palmitic acids, of optimal concentration, in nonpolar kerosene have been used. A table of relative values of absorbed energy $(A - q) \cdot 100/A$ [A specific cutting work, q specific cutting heat] for the various media are given. The average from 10 tests of these values are:

For nonpolar kerosene	2.5
Solution in nonpolar kerosene of caprylic acid of concentration 288 (mM/1)	0.8
Same of palmitic acid of concentration 8	1.6
Same of heptyl alcohol of concentration 343	1.8
Same of ceytl alcohol of concentration 61	1.1

From the same table it is seen that, within about 3%, the cutting work is transformed completely into heat.

Authors conclude by stating that the practical equality of cutting work and heat permits the use of the calorimetric method for investigation of the influence of active liquid media on the process of metal cutting.

D. Mazkevich, USA

923. **Manley, R. A., Drilling small holes,** *Machinery, Lond.* **80**, 2064, 990–991, June 1952.

Subject is very important in the production of diesel and petrol atomizer jets, spinnerettes for synthetic yarn, watches and clocks, surgical instruments, viscosity meters, etc. The six types of drills made are: two-fluted spiral, slow two-fluted spiral (made to 0.004-in. diameter), single-fluted spiral, straight (to 0.014 in.), pivot (made down to 0.002 in.), and flat (to 0.010 in.). The flute length of a standard microdrill, as these drills are called, is usually 7 times the diameter, but it may be as much as 20 diameters.

Author recalls the known fact that the speeds cannot be determined on the basis of recommended surface speed. A 0.002-in. diam drill may be run for steel between 1200 and 4000 rpm. For brass, a 0.010-in. diam drill can be run at 10,000 to 15,000 rpm. A graph of rpm vs. drill size in mm for brass, mild steel, and stainless steel is given. The lubricant must be carefully chosen, and author recommends commercial paraffin. Author reports that 7000 holes have been drilled through 0.040-in. thick alloy steel with a single 0.0062-in. diam drill. Several operations are described briefly.

D. Mazkevich, USA

924. Ford, H., and Ellis, F., Cold rolling with strip tension. Part II. Comparison of calculated and experimental results, *J. Iron Steel Inst.* **171,** part 3, 239–245, July 1952.

The approximate method of calculating roll force and roll torque, described in AMR **6**, Rev. 162, is compared with the recently published experimental results of Hessenberg and Sims. Agreement is very satisfactory over a wide range of reductions and tension.

It is also found that, except for very small passes, the elastic compression at the entrance to the roll causes negligible difference in the roll force. The contribution of the elastic effect at the exit, however, is not negligible. For small passes, the combined effects may amount to as much as 15% of the total roll force.

B. W. Shaffer, USA

925. Bland, D. R., and Ford, H., Cold rolling with strip tension. Part III. An approximate treatment of the elastic compression of the stiip in cold rolling, *J. Iron Steel Inst.* **171,** part 3, 245–249, July 1952.

By making very simple assumptions about the boundary conditions on the elastic zones within the strip, approximate equations are derived which show the contribution of these zones on the roll force and roll torque.

B. W. Shaffer, USA

926. Emicke, O., New results of rolling-mill investigations and their application in rolling-mill practice of warm and cold rolling of metals, especially light metals with aluminum base (in German), *Schweiz. Arch.* **18,** 6, 189–206, June 1952.

Paper is a comprehensive review of the article of warm and cold rolling of aluminum sheet and plate with applications of the theory developed by various researchers, including the work of O. Emicke, Lucas, Siebel, Pomp, Fink, Puppe, Lueg, and Ford. Some of the fundamental developments formerly published by Puppe and Pomp have been reorganized and reproduced in the form of seminomographic charts to indicate the roll pressures and given amounts of reduction of billets of a given thickness when rolled at various temperatures. Author then developed fundamental relationships for the effect of rolling under known back and forward tensions showing, for the first time, the effect of stretching direct stresses on the roll pressures. Seminomographic charts are shown for the rolling of sheet and plates under direct tension when they have previously undergone varying amounts of cold deformation by rolling. The charts show not only the rolled pressures but also the resisting moment which must be overcome by the rolls in order to pull the material through the rolls. The quantities presented are in sufficient fundamental units so as to make them readily translatable into practical regulations for rolling-mill use.

R. G. Sturm, USA

927. Lenz, D., The deformation condition in warm deep drawing (in German), *Arch. Eisenhüttenw.* **23,** 5/6, 173–181, May/June 1952.

Description of deep-drawing experiments whereby the parts of the material that are deformed are kept at higher temperatures (up to 400 C), whereas the punch is cooled. Materials used are aluminum, hard-rolled or with recrystallization texture, and texture-free alloys Al-Cu-Mg, Al-Mg 3, and Mg-Mn. Lubrication is done preferably with oildag.

Improved results are obtained as compared with cold working. The changes in material thickness can be kept low, in general below 10%, and greater drawing ratios can be obtained. Assuming constant thickness of the material, the theoretical relation $R^2 = R_0^2 - 2\,hr$ (with R = instantaneous radius of disk, R_0 original radius of disk, h height of cylinder, r radius of cylinder) when using oildag lubrication, is reproduced experimentally, between wide limits, independent of the value of the clamping pressure.

C. Zwikker, Holland

928. Shaw, M. C., and Smith, P. A., Metallurgical considerations in machining. I, II, III, IV, V, *Amer. Machinist* **95,** 17, 19, 21, 22, 23; 89–92, 139–142, 130–132, 100–103, 138–141; Aug., Sept., Oct., Nov. 1951.

Series reviews metallurgy of ferrous work materials, properties of ferrous, cast alloy, and sintered carbide tool materials; presents theory of tool wear and its relation to metallographic structure. Factors producing tool wear are considered to be plowing by hard particles in work matrix, plowing by work-hardened metal produced by pressure welds, transfer of metal arising from temperature welds. Theoretical considerations are presented, relating form of tool life—cutting-speed curves to relative contributions of above factors. Way in which metallographic structure of work should affect these contributions is discussed in terms of actual tool-life data. No experimental results are presented to corroborate theoretical considerations.

M. Eugene Merchant, USA

929. Betz, W. C., Form-grinding of carbide tools, *Machinery, Lond.* **81,** 2070, 101–102, July 1952.

Paper describes methods, more accurate than free-hand grinding, for grinding radii or other shapes on carbide tools.

D. Mazkevich, USA

930. Stover, A., Cooper, R. W., and France, W. F., Helical carbide milling cutters, *Machinery, Lond.* **81,** 2082, 804–808, Oct. 1952.

These cutters are used at the Boeing Airplane Co., normally at three times the speed of usual cutters. An additional advantage over straight-blade cutters is the reduction of any tendency of the carbide blades to chatter or crumble under impact. On 75S aluminum in slab-milling spars, speeds up to 6500 surface fpm, which for a 7-in. diam cutter corresponds to 3550 rpm feed 280 in./min, have been possible with a cut depth of $^1/_{16}$ in. The 7-in. diam cutter is provided with four carbide blades, each 6 in. long. For same operation and cutter diameter, two blades have also been used. The chip load for the 4- and 2-blade cutters is normally 0.015 in. Authors do not recommend two-flute designs for small diameters. The cutter life has increased by about 450%.

SAE 4340 steel, heat-treated to a tensile strength between 180,000 and 200,000 psi, is cut at a surface speed of 200 fpm, with a feed of 10 in./min, removing stock to a depth of 0.1 in.

A drawing with details of typical cutters for aluminum and steel is given.

The heating of the blades to 2300 F, necessary to twist the blades to the desired helix angle—15 to 20 deg—is described and illustrated.

The paper is interesting and inspiring for every engineer having to do with metal cutting. A short description of the way the high speeds are obtained and the chips carried away, in aluminum cutting, would have been a welcome addition.

D. Mazkevich, USA

931. **Schroeder, W., Pressures required for thin press forgings,** ASME Spring Meeting, Seattle, Wash., Mar. 1952. Paper no. 52-S-4, 12 pp., 13 figs.

Equations are derived for estimating the pressure required for forging thin-skinned parts with parallel trapezoidal stiffeners. The relationship between some nondimensional ratios, established in the derivation, is presented in design charts.

The derived equations are approximate, because a number of simplifying assumptions had been incorporated in the analysis, and some effects had been omitted entirely. Furthermore, author did not realize that his proposed stress-field solution did not satisfy velocity boundary conditions. B. W. Shaffer, USA

Hydraulics; Cavitation; Transport

(See also Revs. 842, 868, 949, 954, 1038, 1089, 1093)

932. **Escande, L., Spillway dams with a suction fissure** (in Italian), *Energia elett.* **29**, 6, 363–374, June 1952.

Through a fissure opened near the top of a spillway dam, a suction on the boundary layer of the overflowing stream can be exercized by a pumping or siphon device. The resulting depressions in the lower region of the stream yields an increase of the discharge coefficient. Author tells of the results of experiments carried out on several types of such spillway dams with suction fissure in the hydraulics laboratories of Toulouse and Banleve. Depressions and discharge coefficients were measured. The stability of the efflux was also investigated in presence of piers and weirs. D. Citrini, Italy

933. **Sliosberg, P., Air tank design** (in French), *Houille blanche* **7**, 3, 377–393, May/June 1952.

Practical examples are developed of pressure-surge calculation in discharge pipes with air tanks. In first part of paper, calculations are carried out neglecting finite wave velocity in pipe, thus following procedures known for a long time. In last part, finite velocity is taken into account, making use of well-known Schnyder-Bergeron graphical method. G. Evangelisti, Italy

934. **Clarion, Claire, Transitory régime in a pressure line with a surge tank after rapid closure of a valve situated immediately below the tank** (in French), *C. R. Acad. Sci. Paris* **235**, 1, 17–19, July 1952.

Paper deals with the oscillations in a hydraulic system with pressure pipe and surge tank but no pipe line, the valve at the base of the surge tank being closed suddenly. The viscosity of the liquid is being considered. Author refers to several previous publications in the title source where the problem has been analyzed mathematically, and publishes in this note a curve showing agreement between tests and mathematical analysis.

C. Jaeger, England

935. **Escande, L., Analytical method for calculation of surge tanks with spillway** (in French), *C. R. Acad. Sci. Paris* **235**, 5, 338–340, Aug. 1952.

936. **Prigogine, I., and Marechal, J., The influence of differences in molecular size on the surface tension of solutions. IV**, *J. Colloid Sci.* **7**, 2, 122–127, Apr. 1952.

The statistical calculation of the surface tension of solutions containing two sorts of molecules, one occupying r sites and the other one site, has been carried out for a simplified model in which only configurations of the molecules parallel to the surface are taken into account.

For this model, it is possible to deduce very simple explicit formulas, which are used for a qualitative discussion of the surface tension of polymer solutions. [See also Prigogine, AMR **5**, Rev. 2401.] From authors' summary by B. R. Mead, USA

937. **Huetz, J., Contribution to the study of the viscosity coefficient of liquids** (in French), *Publ. sci. tech. Min. Air, Paris*, no. 260, 70 pp., 1952.

Rotating viscometers rather than viscosity is the subject of this two-part thesis.

The first part investigates the anomalously high viscosity coefficients observed by Guilket in a rotating sphere viscometer. Huetz's experiments show, first, that if the ratio of rotational speed to viscosity is sufficiently small, the anomaly vanishes; i.e., that the assumption of planar particle motion and the use of Stokes equations are valid. As the above ratio is increased, the torque-vs.-speed curves show one or more small but abrupt increases in slope, and become a series of straight line segments. The increased drag, therefore, does not result directly from inertial (quadratic) terms. The onset of the anomalous regions is shown to coincide with the appearance of nonplanar particle motion. The anomalies are attributed to an indirect inertial effect which brings about circulation in meridional planes. Assumption of discontinuous particle velocities is required. Only effectively infinite cylinders of revolution are said to be free of these effects.

The second part discusses a viscometer based upon Reynolds' theory of the oil wedge in a lubricated bearing. The viscometer consists of two cylinders, one of which rotates inside the other, whose axes are parallel but not collinear. The eccentricity is fixed by external bearings. Huetz shows that the pressure developed in the oil wedge does follow classical theory near the region of maximum pressure, but does not in the widest part of the wedge, where a reversed circulation occurs. Huetz suggests use of this device as a continuous viscosity monitor for lubricants in rotating machinery. F. G. Blake, Jr., USA

938. **Gutmann, F., and Simmons, L. M., The temperature dependence of the viscosity of liquids,** *J. appl. Phys.* **23**, 9, 977–978, Sept. 1952.

Recently Doolittle [see AMR **5**, Rev. 1114] has tried to show that interpolation formulas reproducing dependence of viscosity on temperature within the accuracy of measurements are necessarily so complicated that they are not likely to promise physical significance. He has found that the formula

$$\ln\eta = -A_1e^{500/T}[-Ei\,(-500/T)] - 4.66 + C_1e^{500/T}$$

is able to represent satisfactorily the viscosity data of n-alkanes with a molecular weight up to 240. As opposed to Doolittle's assertion, authors state that the theoretically derived Andrade's equation

$$\eta = A'e^{E/kT}$$

is indeed proper to represent the viscosity measurements, if one supposes that the activation energy E contained in this formula, depending on the coordination of the molecules and ions in the liquid, is not constant, but varies with temperature: $E = E_0 + f(T) = E_0/\Phi(1/T)$. By expanding Φ as a power series in $1/T$, cutting off the series behind the second term, and inserting the expression for E into Andrade's equation, one attains Vogel's formula

$$\eta = A'e^{E'/k(T+c)} \text{ or } \ln\eta = A + B/(T + c)$$

Authors, evaluating the values of the constants of n-alkanes for Doolittle's and Vogel's equations by least-square analysis, state, based on a comparison of the Gaussian criteria of closeness of fit,

that in no case is Doolittle's equation preferable to Vogel's equation. Furthermore, they show that, while Doolittle's formula is restricted to the n-alkanes with a molecular weight up to 240, Vogel's equation is quite adequate in representing temperature-viscosity data for representatives of widely differing classes of liquids. Ulrich Rost, Germany

939. Grunberg, L., Viscosity and constitution (in German), *Kolloid Z.* 126, 2/3, 87–97, May 1952.

Picturing a liquid as a collection of small ordered units which continuously exchange molecular partners and in which volume increase on melting and thermal expansion has caused appearance of holes, and assuming freedom of rotation for molecules and therefore isotropic fields of force and spherical shape of units, author shows how nature of intermolecular forces and shape and internal mobility of molecules influence viscosity η in its dependence upon temperature T. Most viscosity equations express this dependence by exponential formula in which $\eta = \alpha \exp (E_{visc}/RT)$. M. Reiner, Israel

940. Codegone, C., Viscosity of gases and vapors (in Italian), *Ric. sci.* 22, 7, 1416–1419, July 1952.

Author applies law of correspondent states of thermodynamics to the viscosity of several gases and vapors. Two diagrams are presented, with dynamic and kinetic reduced viscosities vs. reduced absolute temperatures. Author defines *reduced* viscosity as the relation between viscosity at a given state and value of viscosity at critical point of the fluid. He uses data from several sources and from his own calculations with the rule of the diameter of the saturation curve. With the author's diagrams and critical values, one is enabled to calculate viscosities of several fluids in conditions not generally given by usual tables.

A. Balloffet, Argentina

941. Charron, F., Viscosity under rapidly varying pressure (in French), *Publ. sci. tech. Min. Air, Paris*, no. 268, 30 pp., 1952.

A rolling mass struck a rod connecting pistons in the two ends of a tube filled with liquid. Motion occurred because the lever arms were unequal, one moving in and one out of the tube. From the magnitude of the force, time of application, and piston motion, the viscosity of the liquid could be calculated.

It was found that the viscosity so calculated increased moderately in going from a slow blow and low pressure to a fast blow and high pressure (500 to 1000 atm in 0.02 to 0.04 sec), whereas the viscosity was considerably higher at the same high pressure if the pressure was maintained constant. Thus, the rise in viscosity produced by an increase in pressure has an appreciable time lag before it will show up. Glycerine, which showed an increase in viscosity of 50% in going to 600 atm, showed a negligible viscosity increase if the experiment lasted 0.028 sec only. Also, an oil which had 20 times higher viscosity at 850 atm showed a doubling of the viscosity if the test lasted 0.02 sec. Thus, a liquid with a higher pressure dependence of viscosity has a shorter time lag for the effect to show up.

Adiabatic compression and friction heat up the liquids slightly, but much less than enough to account for the results.

C. F. Bonilla, USA

942. Umstätter, H., Viscosity as a material constant (in German), *Kolloid Z.* 126, 2/3, 108–117, May 1952.

The existence of a functional correlation between elastic moduli, including compressibility, and the constant of viscosity of a fluid is developed. These relations are of practical interest, since the viscosity values of plastics may be difficult to measure, yet the measurement of an elastic modulus is easy.

W. L. Sibbitt, USA

943. York, J. L., and Stubbs, H. E., Photographic analysis of sprays, *Trans. ASME* **74,** 7, 1157–1161, Oct. 1952.

See AMR **5,** Rev. 1442.

944. MacLellan, A. G., A statistical-mechanical theory of surface tension, *Proc. roy. Soc. Lond.* (*A*) **213,** 1113, 274–284, June 1952.

Surface tension is considered from standpoint of the physical chemist as isothermal derivative of free energy of molecules of fluid. It is shown that, for a one-phase system, the thermodynamic pressure depends on the values, at the center of the container, of the number density and the pair-distribution function. Two types of surface tension are considered, that at the walls of the container and that at the surface between the liquid and the vapor. For a two-phase system, the tension of a plane surface between phases is given by an approximate formula which depends on a suggested approximate form for the pair-distribution function.

From author's summary by W. D. Baines, Canada

Incompressible Flow: Laminar; Viscous

(See also Revs. 754, 784, 934, 996, 999, 1006, 1023, 1040, 1140)

945. Ackeret, J., On the exact solutions of the Stokes-Navier equations of incompressible fluids for modified boundary conditions (in German), *ZAMP* **3,** 4, 259–271, July 1952.

Author considers steady, plane, irrotational flow of a viscous incompressible fluid. In order to satisfy the condition of vanishing velocity at a solid boundary, it is assumed that every point of the boundary moves in a direction tangential to the boundary and with a velocity equal to that of the potential flow at that point. Expressions for the energy dissipation are developed, and the dissipation is calculated for several specific problems. Results for the analogous theory for flow about a sphere are presented.

For high Reynolds numbers, the dissipation is extremely low when compared with the dissipation in the usual viscous flow problem in which the boundaries do not move. While it is probably impossible in reality to satisfy the boundary conditions required by irrotational flow, author believes that even a partial fulfilment of these conditions may be of great significance in reducing dissipation. G. W. Morgan, USA

946. Hannah, D. M., Forced flow against a rotating disc, *Aero. Res. Counc. Lond. Rep. Mem.* 2772, 17 pp., Apr. 1947, published 1952.

Problem of steady incompressible irrotational viscous flow with axial symmetry against an infinite rotating disk is solved numerically. Closed solution for nonviscous fluid is obtained by method of sources and used as guide for solution of case of viscous fluid. Exact Navier-Stokes equations are reduced to a pair of ordinary nonlinear differential equations in two unknown functions of the axial coordinate, and are solved by a numerical integration method. Results are presented for entire angular velocity range, including corrections of previous results obtained by Hömann for the nonrotating disk. Author shows that effect of motion of disk on fluid velocity is perceptible only in a layer of thickness predicted by usual boundary-layer analysis.

L. L. Cronvich, USA

947. Kramer, J. J., and Stanitz, J. D., Two-dimensional shear flow in a 90° elbow, *NACA TN* 2736, 44 pp., June 1952.

Using relaxation method, solutions are obtained for nonviscous incompressible shear flows in a two-dimensional channel consisting of a 90° elbow. The particular channel chosen for these solu-

tions was originally designed for absence of local decelerations along channel walls with incompressible, potential flows. Solutions for shear flows show that separation can occur without viscosity.

Hsuan Yeh, USA

948. **Wada, Y., On the recurrent figure of a jet,** *J. phys. Soc. Japan* **7,** 2, 211–214, Mar./Apr. 1952.

Author considers the standing waves on the surface of a circular jet and demonstrates that for a given mode there exists a minimum velocity which is inversely proportional to the radius of the jet. Using the results of a previous computation [title source, 5, 1950], he is able to extend Rayleigh's results for the jet [*Proc. roy. Soc.* **29,** 1879] to show that, with increasing velocity, waves of successively higher mode are superposed, and that, above the minimum velocity, two wave lengths are coexistent, in analogy to Rayleigh's results for a plane surface [*Proc. Lond. math. Soc.* 15, 1883].

Phillip Eisenberg, USA

949. **Ericksen, J. L., Thin liquid jets,** *J. rational Mech. Analysis* **1,** 4, 521–538, 1952.

A theoretical treatment is given of thin jets of liquids with free boundaries, which are subject to body forces (e.g., gravitation) or surface tension (due to capillary forces). Theory is developed for general case of axially unsymmetric jets. The pressure difference between free boundary and surrounding medium (at rest) is assumed proportional to mean local curvature of surface of jet. An initial value problem is formulated, and general properties of solutions are discussed. Certain classes of solutions are found, which are rather limited for the case of constant body-force vector, but more general for the case of vanishing body forces. No particular examples are calculated and no comparison is made with experiments.

H. Schuh, Sweden

950. **Ménard, M., Contribution to the aerodynamic study of airfoils and airscrews** (in French), *Publ. sci. tech. Min. Air, Paris* no. 262, 187 pp., 1952.

This book-length work is an attempt to solve a number of diverse problems relating to wings and propellers in an incompressible fluid.

The first problem to be considered is that of determining a correction to the forces and moments measured in a conventional two-dimensional wind-tunnel test to account for the influence of the boundary layers on the side walls. The analysis is performed, using Prandtl's lifting-line concept to represent the wing and logarithmic velocity profiles near the side walls to simulate turbulent boundary layers.

The second major topic is the presentation of a new lifting-line theory and a new lifting-surface theory for the determination of the aerodynamic characteristics of wings of finite span. Although both methods have their origin in Prandtl's wing theory, they differ from the classical theory in that the trailing vortex system is considered to be composed of only two vortexes, each trailing straight downstream from a wing tip. The velocity field of each of the trailing vortexes is identified with that of an isolated line vortex in a viscous incompressible fluid. The resultant velocity field is found by superposition, and the remainder of the analysis follows in a manner more or less analogous to that of classical wing theory. Author summarizes the relation between his theory and Prandtl's theory as follows: Prandtl's theory is in accord with Helmholtz's vortex laws but not with experiment. Author's theory is in accord with experiment but not with the vortex laws. The principal discrepancy noted between experiment and classical theory is that the latter underestimates the lift near the tip of a rectangular wing. Although the new theory is indicated to be in much better accord with experiment in this particular, it is reviewer's opinion that the added lift is due not so much to the influence of the trailing vortex system as to a local separation of the flow around the wing tip.

The third topic is an experimental investigation of the aerodynamics of propellers. The investigation centers around a novel method for determining the effective angle of attack of a blade section by measuring the static pressure at three points situated near the leading edge. Author then shows that this information can be used, together with airfoil data, to determine the thrust and torque of an operating propeller. Finally, author proposes two new methods for the theoretical determination of propeller characteristics, based on the same concepts as the new wing theories described above.

John R. Spreiter, USA

951. **Couchet, G., Aerodynamic forces on a wing with arbitrary motion in a fluid at rest at infinity** (in French), *ONERA Publ.* 56, 32 pp., 1952.

For a profile having constant circulation and moving in the presence of free vortexes in the fluid, it is shown that the aerodynamic forces can be calculated without being troubled by the presence of the free vortexes. The motion of a sharp-edged profile which is continuously discharging vortexes is then treated as consecutive, constant-circulation motions. The vortex wake and aerodynamic forces are calculated.

G. E. Nitzberg, USA

952. **Biésel, F., General second-order equations of irregular waves** (in French), *Houille blanche* **7,** 3, 372–376, May/June 1952.

"Irregular waves" are waves which do not have a simple harmonic character but result from superposition of a given number of elementary harmonic waves.

Author studies solutions of second approximation for these waves, and writes, without demonstration, general equations for progressive waves and for "clapotis." Principal results are that, in second-order approximation, not only the waves of first order are present, but also waves with half wave length and same velocity; on the other hand, waves with length and velocity almost equal to the corresponding characteristic of the first-order waves' groups are also present. Author also gives solution of second order for the simple case of superposition of two harmonic waves in finite depth.

Giulio Supino, Italy

953. **Topakoglu, C., Steady laminar flow of an incompressible fluid through a curved pipe of circular cross section** (in Turkish), Istanbul tekn. Üniv., 30 pp., 1951.

Author investigates the flow of a steady, incompressible, viscous fluid in a torus of circular cross section. Flow variables are assumed to be expandable into ascending powers of the curvature of the central line of the torus. Thus, using the curvature as a perturbation parameter, Navier-Stokes equations are reduced to an infinite set of inhomogeneous harmonic and biharmonic equations. Solutions are given up to and including third power of the perturbation parameter. The formulas are valid for small curvature. It is shown that the flux is a function of both Reynolds number and the curvature of the pipe.

Limitation of the present theory is not indicated. Paper does not contain any numerical computation; nevertheless, author is successful in giving a rational approach to this difficult problem.

A. C. Eringen, USA

954. **Hall, N. A., Orifice and flow coefficients in pulsating flow,** *Trans. ASME* **74,** 6, 925–928, Aug. 1952.

See AMR **5,** Rev. 1857.

955. **Sibulkin, M., Heat transfer near the forward stagnation point of a body of revolution,** *J. aero. Sci.* **19,** 8, 570–571, Aug. 1952.

The energy equation for incompressible flow is solved in the

vicinity of the forward stagnation point, neglecting dissipation and pressure terms and conduction normal to the stagnation streamline. A numerical integration, utilizing the stagnation-point boundary-layer velocity distribution of Homann [*ZAMM* **16**, p. 159, 1936], yields an expression for the heat-transfer coefficient. There is no discussion of the possible consequences of the various assumptions, or of the fact that the Homann velocity distribution becomes infinite. S. A. Schaaf, USA

956. Bryson, A. E., Note on aerodynamic heating with a variable surface temperature, *Quart. appl. Math.* **10**, 3, 273–275, Oct. 1952.

Paper is a continuation of the work by Emmons [AMR **4**, Rev. 2571], who considered the problem of an insulated flat plate of infinite extent started impulsively from rest in a viscous, incompressible fluid. This note deals with the same problem, but instead of an insulated plate, a plate with a surface temperature that is a given function of time is considered. The temperature distribution and the heat flow through the surface of the flat plate are obtained in integral form. Author, following Rayleigh, then replaces the time t by x/U, where U is the undisturbed velocity, and gets a solution for the steady flow past a semi-infinite flat plate with an arbitrary surface temperature. The heat flow through the surface of the plate is obtained in integral form.

Author compares this result with that which Lighthill [AMR **4**, Rev. 2612] obtained in quite another way for the same problem. The results are similar. The Lighthill solution holds for large Prandtl numbers, and reviewer believes that the Bryson results hold for small Prandtl numbers. Tore Gullstrand, Sweden

957. Lessen, M., Some considerations of the stability of laminar parallel flows, *J. aero. Sci.* **19**, 7, p. 492, July 1952.

The fundamental equations and boundary conditions of two-dimensional disturbance for a plane quasiparallel laminar flow are stated. They are reduced to simpler forms for the cases of (1) incompressible flow with variable viscosity, (2) laminar "mixing" of dissimilar fluids, and (3) compressible flow where the density perturbation is of higher order than the velocity perturbation.

In the second case, the molecular diffusion or "mixing" between the dissimilar fluids is neglected; reviewer believes that it is rather a serious restriction for this case. S. I. Pai, USA

958. Pond, H. L., The moment acting on a Rankine ovoid moving under a free surface, *David W. Taylor Mod. Basin Rep.* 795, 17 pp., Nov. 1951.

In calculations of the forces acting on a body submerged in an unbounded fluid, it is usually convenient first to replace the body itself by a system of singularities (sources, sinks, doublets, etc.), and then to operate with this system. The introduction of external boundary conditions (viz., free or rigid surfaces) modifies the system of singularities required to represent the body. Such modification usually has only a small effect on the vertical and horizontal forces generated; consequently, when calculating lift or resistance of a body near a free surface, a sufficiently close approximation is given by the system of singularities representing the body in the unbounded fluid. Such first approximation, however, is no longer valid when calculating the moment acting on the same body. To obtain a reasonable approximation in this case, the singularity system needs to be modified to account for the waves formed by the motion of the body. Within the approximation considered, such modification gives rise only to a couple (pitching moment) and does not affect the vertical or horizontal forces acting on the body.

Author obtains solution for moment acting on a Rankine ovoid moving under the free surface of a fluid of infinite depth. In this case, the effect of the velocities induced by the free surface is accounted for by a suitable distribution of doublets along the axis of the stream surface between source and sink. M. St. Denis, USA

959. Havelock, T. H., The moment on a submerged solid of revolution moving horizontally, *Quart. J. Mech. appl. Math.* **5**, part 2, 129–136, June 1952.

Author first considers the forces acting on a prolate spheroid moving horizontally directly beneath the free surface. He gives the velocity potential for the axial motion of such bodies in an unbounded medium in terms of the axial distribution of doublets, and calls attention to the fact that this is equivalent to expressing prolate spherical harmonics in terms of axial distributions of poles or multipoles. A general formula is given explicitly. Lagally's theorem is employed to give the wave resistance which is presented in explicit form and the vertical force which is not expressed. The moment requires a further approximation to the velocity potential. It is calculated as the sum of two terms, the first of which is calculated in the usual way from the first approximation of the wave potential; the other is given by the moment of some distribution of sources and sinks within the spheroid. This distribution turns out to be a line of doublets having axes parallel to the vertical axis of the body. This result was given by Pond (see preceding review). This second term turns out to be jointly proportional to the speed squared, the wave resistance, and the ratio of the virtual mass in transverse motion to that in axial motion. The total moment at low speed is found to be positive or negative depending upon Froude number, but beyond a length Froude number of 0.40 the moment is always negative (bow tends to be rotated downward) and has a very simple asymptotic formula for large Froude numbers. Author proposes that, for any slender body of revolution, the second term for the moment be taken as $-2\ RC^2/g$, R being the wave resistance, C the speed, and g the acceleration of gravity. He applies this approximation to a Rankine solid and gives graphs of calulated results. J. P. Breslin, USA

Compressible Flow, Gas Dynamics

(See also Revs. 1005, 1035, 1039, 1040, 1082, 1083, 1098, 1100, 1101)

960. Lance, G. N., The drag on slender pointed bodies in supersonic flow, *Quart. J. Mech. appl. Math.* **5**, part 2, 165–177, June 1952.

Drag of a smooth slender body pointed at nose and moving at supersonic velocity in direction x parallel to its longitudinal axis is calculated, using inviscid linearized "slender-body" theory. Cross-section shape is arbitrary, but distribution of cross-section area $S(x)$ must be such that $S'(l)$ vanishes (l is body length). Two alternate integral expressions are obtained, each equivalent to von Kármán's integral for drag. One integral involves $S''(x)$, and the other involves the Fourier transform of $S'(x)$. Author states that these new integrals are simpler to manipulate for a given body than is von Kármán's integral. D. R. Chapman, USA

961. Whitham, G. B., The flow pattern of a supersonic projectile, *Comm. pure appl. Math.* **5**, 3, 301–348, Aug. 1952.

Solutions of linearized equations of motion for inviscid, nonconducting compressible fluid suffer from disadvantage that they do not give a uniform first approximation to flow patterns everywhere. This paper is latest of an important series by Lighthill [AMR **3**, Revs. 1295, 1829, 2405; **5**, Rev. 2089] and Whitham

[AMR 4, Revs. 1245, 1248], in which methods of overcoming difficulty have been propounded.

Paper gives a complete first approximation to supersonic flow at moderate Mach numbers past any slender body of revolution. Method depends on fundamental hypothesis that linearized solution gives correct first approximation to flow everywhere, provided that values of velocity, etc., predicted at given distance from body axis on approximate (linear) characteristic pointing downstream from a given point on body surface, are interpreted as values at same distance from axis on exact characteristic pointing downstream from same point on body surface. Consequences of hypothesis are developed in detail, and results substantiate its validity.

Determination of flow pattern is shown to depend upon a certain function $F(y)$; for smooth bodies $F(y) = {}_0\int^y (y - t)^{-1/2} S''(t)\, dt$, where $S(x)$ is cross-section area at distance x from nose; when $S'(x)$ is discontinuous, expression for $F(y)$ is more complicated. Shock positions are determined by elegant geometrical construction from plot of $F(y)$. Drag is given by $\pi \rho_0 U^2 {}_0\int^\infty F^2(y)\, dy$, a result previously published by G. N. Lance (see preceding review). Flow pattern at large distances from axis has been given by author in previous paper [AMR 4, Rev. 1245], results of which led him to formulate hypothesis.

Similar hypotheses can be formulated for other hyperbolic problems in two variables, and consequences of these for two-dimensional steady supersonic flow, one-dimensional unsteady flow, and spherically symmetrical unsteady flow are discussed briefly in appendix.

Proof of general hypothesis of this kind is now required and should not be too difficult to achieve; then, limitations of author's hypothesis will be known more precisely, and general application of result may be expected to lead to further important advances in theory of approximate solutions of nonlinear hyperbolic equations.

G. N. Ward, England

962. **Chang, C.-C., and Werner, J., A solution of the telegraph equation with application to two-dimensional supersonic shear flow,** *J. Math. Phys.* **31,** 2, 91–101, July 1952.

The linearized problem of two-dimensional supersonic shear flow is reduced, in a particular case of Mach number profiles, to the telegraph equation. By applying Riemann's method of integration, one obtains an integral relation where some of the Cauchy data are the unknown which one has to determine. In this way, the integral relation becomes a Volterra integral equation of the first kind. Author applies Laplace transform technique to solve this integral equation. Some examples (shear flow over a wedge and a parabolic arc profile) are discussed.

Robert Sauer, Germany

963. **Hjelte, F., Velocity distribution on a family of thin conical bodies with zero incidence according to linearized supersonic flow theory,** *Roy. Inst. Technol., Div. Aero., AERO TN* 22, 16 pp., 1952.

Source-distribution method for conical flow is applied to determine velocity distribution over thin cones with two orthogonal planes of symmetry whose surface can be represented or approximated by linear combination of certain simple functions derived in text. Additional functions required in the computations are plotted and tabulated.

W. E. Moeckel, USA

964. **Behrbohm, H., The lifting trapezoidal wing with small aspect ratio at supersonic speed,** *SAAB Aircr. Co., Linköping, TN* 10, 37 pp., 1952.

Author considers the linearized supersonic flow past flat plate wings with trapezoidal planform, i.e., with leading and trailing edges normal to the undisturbed stream direction and side edges swept back within the corresponding Mach cones. A method of supersonic sources is used to determine the potential in the several regions of the disturbed field, bounded by the traces of the Mach cones from the leading edge corners and their reflections at the side edges; only first reflections are considered. The source strength is found from the solutions of Abelian integral equations. Pressure distributions, lift-curve slopes, and centers of pressure are computed for angles of sweepback of 90, 75, and 60°.

Most of the results could be obtained by the more general methods of Evvard [AMR 4, Rev. 3310] and Ward [AMR 3, Rev. 1992], developed for application to any wing planform with convex boundary.

Maurice Holt, England

965. **Bleviss, Z. O., Interference effects in supersonic flow** (Thesis), Cal. Inst. Technol., xi + 223 pp., 1951.

The thesis presents a compilation of theoretical work on the supersonic lift and damping in roll due to fin-fin interference, wing-body interference, and wing-body-tail interference. The main results are based on previous work by the author on fin-fin interference, with only slight attention to the wing-body and wing-body-tail problems.

Fin-fin interference is defined as the force produced by the interaction of one surface of a plane or cruciform fin configuration on the other surfaces. The forces are computed by linear theory with some difficult cases bracketed by overestimates and underestimates. Slender-body theory is occasionally applied to improve these estimates.

For the most part, the results of previous work in the field are set down in their proper relation to the interference problem, but very little new material is presented. An extensive bibliography lists most of the primary sources for those interested in pursuing the problem further; numerous charts and figures suitable for design use are presented for those primarily interested in the results.

L. H. Schindel, USA

966. **Ferri, A., The method of characteristics for the determination of supersonic flow over bodies of revolution at small angles of attack,** *NACA Rep.* 1044, 16 pp., 1951.

Supersedes paper reviewed in AMR **3,** Rev. 1321.

967. **Ferri, A., Supersonic flow around circular cones at angles of attack,** *NACA Rep.* 1045, 11 pp., 1951.

Supersedes paper reviewed in AMR **4,** Rev. 1650.

968. **Kraus, S., An analysis of supersonic flow in the region of the leading edge of curved airfoils, including charts for determining surface-pressure gradient and shock-wave curvature,** *NACA TN* 2729, 45 pp., June 1952.

This is a study of conditions at and behind an attached shock wave near the leading edge of a curved airfoil in supersonic flow. The surface-pressure gradient and the shock-wave curvature at the leading edge are calculated according to the theory of Munk and Prim, both for an ideal and for a calorically imperfect diatomic gas. The results are compared with the corresponding quantities provided by shock-expansion theory. It is found that the latter (which is only approximate) is satisfactory so long as conditions of shock detachment are not approached.

The report includes a method for calculating the field of flow a short way downstream of the leading edge. It is based on the assumption that the Mach lines emanating from the airfoil in that region can be represented approximately by circular arcs.

Numerous tables and charts are presented.

A. Robinson, Canada

969. Donaldson, C. duP., and Lange, R. H., Study of the pressure rise across shock waves required to separate laminar and turbulent boundary layers, *NACA TN* 2770, 20 pp., Sept. 1952.

A dimensional study is made of factors which influence the separation of a turbulent and laminar boundary layer in supersonic flow on a flat plate. The critical pressure across a shock wave which just causes separation is proportional to the skin friction. With usual assumptions for skin friction, this means that the critical pressure is proportional to the Reynolds number to the $-^1/_2$ power for laminar boundary layers, and to the Reynolds number to the $-^1/_5$ power for turbulent boundary layers.

An experimental investigation was conducted in the Langley blowdown jet at a Mach number of 3.03 and Reynolds number range from about 2 million to 19 million. The interaction of shock wave and boundary layer was investigated when the boundary layer was caused to separate from the surface of a tube of large diameter compared with the boundary-layer thickness by means of a collar mounted on the tube. The experimental results are in general agreement with the theoretical predictions.

The significance of the results obtained is discussed relative to certain practical design problems, such as supersonic-diffuser design. Tore Gullstrand, Sweden

970. Lundquist, G. A., Shock wave formation in a shock tube, *J. appl. Phys.* **23**, 3, 374–375, Mar. 1952.

For the past ten years, the shock tube has been used in the study of all types of one- and two-dimensional flow phenomena. One of the basic parameters to be measured was the speed of the shock wave as a function of diaphragm-pressure ratio.

The results of most experiments have shown that, for low diaphragm-pressure ratios (even up to 100), the speed of the shock wave was in excellent agreement with theory. This also includes the speed of the head of the expansion wave (a Mach wave which is mathematically a characteristic line) from which the speed of sound in gases has been accurately determined experimentally. As the pressure ratio increased up to about ten thousand, the shock-wave speed attenuated to order of about 10%.

The paper under review contends that the reason that the shock-wave speed has been found to attenuate is due to the nearness of the time base to the diaphragm where the velocity measurements were made, because near the diaphragm the plane shock wave is not fully formed. Experimental evidence obtained in a $20 \times 20\text{-cm}^2$ shock tube is presented, which shows essentially complete agreement with theory when velocity measurements are taken about 26 cross-section widths (5.1 ms) from the diaphragm. The details of the time-base length, the number of repeated measurements, or the manner in which the diaphragm ruptures are not given.

In a tube of this size, the diaphragm material is thick. The manner in which such a diaphragm ruptures is far from ideal, and it can produce a real discontinuity in tube cross section. The effects of the diaphragm-bursting energy and of the shattered pieces on the flow are not considered, and boundary-layer effects over large distances are ignored. Yet, in spite of the omission of these important factors, there is extraordinary agreement with the ideal assumptions made in the theoretical analysis.

Reviewer believes that the paper under review has not given a complete explanation of the problem of shock-wave attenuation. Recent detailed experiments conducted at the Institute of Aerophysics, University of Toronto, on a $3 \times 3\text{-in.}^2$ wave-interaction tube which utilized a wave-speed camera to give continuous velocity readings, have shown that the closest agreement with theory for the speed of the shock wave as a function of diaphragm-pressure ratio occurred at a distance of 11 cross-section widths (33 in.) from the diaphragm, whereas at 45 cross-section widths (135 in.) from the diaphragm the results were not quite as good. These experiments also studied the velocity attenuation as a function of diaphragm-pressure differences with a given diaphragm-pressure ratio. This work will be reported in the near future. In general, the results are in agreement with previous experiments; namely, it takes a short distance for the shock speed to become uniform and then the shock speed gradually attenuates. The attenuation is negligible up to a diaphragm-pressure ratio of 100, and is about 10% at pressure ratios of 10,000. The best shock-wave speed results are obtained when pressure difference across the diaphragm is near the point where the diaphragm ruptures. [AMR **5**, Rev. 2967 also deals with this topic.] I. I. Glass, Canada

971. Steketee, J. A., On the interaction of rarefaction waves in a shock tube, *Univ. Toronto Inst. Aerophys. UTIA Rev.* 4, 40 pp., 6 figs., Mar. 1952.

Propagation of complete centered rarefaction wave in one-dimensional flow, and interaction of this wave with its reflection from solid wall are reviewed briefly. Details are given of Riemann integration method of investigating interaction, and motion is calculated explicity for $\gamma = 5/3$ and $7/5$. Theory is applied to real shock tube (expansion chamber not completely evacuated), and time T_4 when constant state region is created is calculated. Graph of T_4 vs. diaphragm-pressure ratio for He-Air, Ar-Air, and Air-Air is given. J. S. Isenberg, USA

972. Grad, H., The profile of a steady plane shock wave, *Comm. pure appl. Math.* **5**, 3, 257–300, Aug. 1952.

This is a study of the distributions of velocity, temperature, etc., within a plane, steady shock front. It begins with a suggestion of a new definition of the "thickness" of such a front. Next, the conservation equations of mass, momentum, and energy are written down, using perfect-gas expressions for internal energy and pressure but leaving the viscous stress and heat conduction unspecified. The Navier-Stokes approximations for these are discussed, as are some special cases, including Becker's famous one of Prandtl number 3/4 [*Z. Phys.* **8**, 1922]. The main point of this paper is to introduce in place of the Navier-Stokes formulas for viscous stress and heat conduction two differential relations involving these, taken from an earlier paper [see AMR **3**, Rev. 2774], called the "thirteen-moment" approximation. (Incidentally, this theory puts the Prandtl number equal to 2/3.) The major part of the paper deals with the solution of the resulting set of equations and the interpretation of the solution. Finally, comparisons are carried out between these results and Navier-Stokes results (for Prandtl number 2/3), for several special assumptions regarding the viscosity-temperature relationship. For one of these assumptions (elastic-sphere molecules), the thickness is plotted against Mach number in comparison with Navier-Stokes results and the results of Mott-Smith [see AMR **5**, Rev. 784]. The thirteen-moment method breaks down completely at Mach number 1.65, but the author seems to think this is a virtue. W. R. Sears, USA

973. Cabannes, H., Study of the attached shock wave in axisymmetric flow. Part two: Case of an obstacle ending with a cone (in French), *Rech. aéro.* no. 27, 7–16, May/June 1952.

In the first part [AMR **5**, Rev. 2421], author studied the flow in vicinity of the ogival tip of an axisymmetric obstacle. In the present part, he outlines the same procedure of series expansion, but allows the series exponents to take nonintegral values. This leads him to prove the nonexistence of Crocco's curvature para-

dox. This concerns the first case, where the velocity on the cone is subsonic and where the perturbation issued from the joining point J of the cone and the obstacle (tangent-, curvature-, or curvature-derivative discontinuity) propagates upstream on the cone and, finally, in the whole region downstream of the shock wave, the equation of which has following form at tip vicinity: $\theta = \theta_\omega + A \cdot r^m + \ldots$ (A and m are, respectively, approximately and exactly calculated). In the second case, the velocity on the cone is supersonic, and study proceeds on the equations of motion written in the characteristic coordinate system. Author distinguishes four flow regions, each of them being not an analytical prolongation of the preceding one. The first one is limited by the Mach line issued from J, which intersects the shock line at I, the straight segment $\overline{OI}$ of the shock line and the meridian segment $\overline{OJ}$ of the cone; the second one by the Mach line $\overline{JI}$ and the second characteristic line issued from I; the third one by that characteristic line and the streamline issued from I. The flow in these three regions is isentropic. The last flow region is limited by the streamline issued from I and the shock line prolongation from I, the corresponding flow being no more isentropic. The curvature discontinuity of the shock line at I is calculated.

The whole study has supplied some precision to the determination of the attached shock wave in axisymmetric flows.

Pierre Schwaar, Switzerland

974. **Mattioli, E., Oscillations of a shock wave in a diffuser** (in Italian), *Aerotecnica* **32**, 3, 143–144, June 1952.

Divergent diffuser with supersonic inlet and subsonic outlet is considered. Effects on shock-wave position of oscillations in inlet or outlet pressures are determined.

N. H. Johannesen, England

975. **Mitchell, A. R., The rotational field behind a bow shock wave in axially symmetric flow using relaxation methods,** *Proc. roy. Soc. Edinburgh* (*A*) **63**, part 4, no. 27, 371–380, 1952.

The relaxation technique of R. V. Southwell is developed to evaluate mixed subsonic-supersonic flow regions with axial symmetry, changes of entropy being taken into account. In the problem of a parallel supersonic flow of Mach number 1.8 impinging on a blunt-nosed axially symmetric obstacle, the new technique is used to determine the complete field downstream of the bow shock wave formed. Lines of constant vorticity and Mach number are shown in the field, and, where possible, a comparison is made with the corresponding two-dimensional problem.

From the author's summary by G. V. R. Rao, USA

976. **Lukasiewicz, J., Conical flow as a result of shock and boundary-layer interaction on a probe,** *Aero. Res. Counc. Lond. Rep. Mem.* 2669, 10 pp., Sept. 1948, published 1952.

The formation of a conical shock and a conical region of flow separation originating from the tip of a thin traversing tube was observed in a supersonic tunnel as a result of interaction of a strong shock with the boundary layer on the tube surface. The angles of the conical shock and separation surfaces and the static pressure in the separation region are in good agreement with the theoretical conical-flow solutions.

The extent of the conical flow illustrated should act as a warning against the use of static pressure tubes for measuring pressures in the regions of strong shocks. From author's summary

977. **Manson, N., and Ferrié, F., Note on spherical explosion waves in gas mixtures** (in French), *C. R. Acad. Sci. Paris* **235**, 2, 139–140, July 1952.

Experimental evidence is presented to demonstrate the existence of spherical detonation waves in gaseous mixtures. Several mixtures were tried. Previous ambiguity was eliminated by using several methods of initiation. Velocity of spherical detonation wave was found to be the same as plane wave in tube.

J. S. Rinehart, USA

978. **Kawamura, R., Reflection of a wave at an interface of supersonic flows and wave patterns in a supersonic compound jet,** *J. phys. Soc. Japan* **7**, 5, 482–485, Sept./Oct. 1952.

Reflection conditions of a weak wave at an interface between two parallel supersonic jets are found by means of linearized characteristic equations. Application is made to a jet of finite width surrounded by another flow with a different Mach number.

G. Guderley, USA

979. **Toose, D. G., The laminar motion of a plane symmetrical jet of compressible fluid,** *Quart. J. Mech. appl. Math.* **5**, part 2, 155–164, June 1952.

A closed analytical solution is obtained for problem under assumptions that (1) Prandtl number is unity, (2) the coefficient of viscosity is directly proportional to absolute temperature, (3) the velocity profiles in jet exhibit similarity at all points downstream of the orifice, (4) no pressure gradient exists in jet, and (5) usual boundary-layer assumptions can be applied. The velocity parallel to the jet axis is obtained as a simple function of the stream function and axial distance. Graphs of velocity and temperature distributions (temperature being obtained from Crocco's relation) are given for various jet Mach numbers and temperatures.

L. L. Cronvich, USA

980. **Szablewski, W., Turbulent mixing of two plane air jets of almost equal velocity and greatly different temperature** (in German), *Ing.-Arch.* **20**, 2, 73–80, 1952.

For turbulent mixing of two uniform streams of different temperatures, author writes the continuity, momentum, and energy equations in a form which he derived in another paper. He uses the concept of constant exchange coefficient which was proposed by Prandtl in 1942, and introduces an empirical number (the transport ratio of substantial properties and of velocities in turbulent mixing). Pressure, as well as specific heat at constant pressure, is taken as constant. The equation of state of ideal gas is used. The velocity distribution of the streams is taken as uniform before mixing. The width of the mixing zone is taken as linearly varying with the distance from the start of the mixing. Transformation into the $\eta = y/x$ plane is used. The resulting equations are rewritten for the case where the velocity difference between the two streams is negligible. Then, the equations are written for the case of negligible temperature difference between the two streams. In the final equations, new independent variables $\sigma\eta$ and $\sigma_*\eta$ are introduced, the first in the continuity and momentum equations, the second in the energy equation. σ and σ_* are functions of x and are "stretching factors." The longitudinal and transverse velocities as well as the temperature profile are plotted along $\sigma_*\eta$ in nondimensional form and for various temperature ratios of the two streams (i.e., 1, 2, 3, 6, 11). It is shown that the mixing zone shifts toward the hotter stream. Finally, it is shown that the assumption of constant pressure is admissible. This is done similar to the analysis of Tollmien in 1926. Some of the assumptions, particularly the one of uniform velocity distributions before mixing, seem to be too restrictive to the reviewer.

T. P. Torda, USA

981. **Shiffman, M., On the existence of subsonic flows of a compressible fluid,** *J. rational Mech. Analysis* **1**, 4, 605–652, 1952.

For given conditions at infinity, there is a unique compressible flow past a two-dimensional obstacle with continuously turning

tangent and bounded curvature, provided the velocity everywhere in the field is subsonic. This result is obtained by considering the differential equation for compressible flow as the Euler-Lagrange equation of a certain variational integral, the domain of integration of the latter being the region exterior to the obstacle and including the point at infinity. Convergence of the integral is established by subtracting suitable terms from the integrand, and further modification is necessary to insure that it is minimized by every subsonic flow. Ordinary methods of the calculus of variations are then applied to the final form of the variational integral, and the uniqueness theorem stated above is established. Most of the difficulties encountered arise in the neighborhood of the obstacle sides and the point at infinity.

By altering the subtractive terms, the case of circulation round the obstacle is considered. The flow, provided it is everywhere subsonic, is still unique for given circulation and conditions at infinity, and the critical Mach number now depends on the circulation as well as on the shape of the obstacle boundary. In conclusion, author points out that the methods used are directly applicable to partial differential equations more general than the compressible-flow equation. A. R. Mitchell, Scotland

982. Cole, J. D., Note on the fundamental solution of $wy_{vv} + y_{ww} = 0$, *ZAMP* **3**, 4, 286–297, July 1952.

Singular solution is obtained for equation which is of mixed type. Results have applications in approximate hodograph theory of transonic potential flow: subsonic for $w > 0$, supersonic for $w < 0$.

Author obtains integral representation of the solution having a logarithmic singularity in elliptic half-plane $w > 0$; solution is not unique but is made so by suitable restrictions on continuation into hyperbolic half plane $w < 0$. Singularity at $w = 0$ is investigated as a special case. Series expansion of the singular part of the fundamental solution is derived from the integral representation, and precise nature of logarithmic singularity for $w > 0$ is exhibited. Treatment is essentially mathematical.

S. Kirkby, England

983. Beckwith, I. E., Ridyard, H. W., and Cromer, Nancy, The aerodynamic design of high Mach number nozzles utilizing axisymmetric flow with application to a nozzle of square test section, *NACA TN* 2711, 30 pp., June 1952.

Authors present method for computing square-test-section high-Mach-number nozzles. Method is based on computation of axially symmetric nozzle of required Mach number, using analytically calculated isentropic radial flow near the throat followed by a downstream characteristics computation to give the desired uniform axially symmetric flow. A square section is then blocked out of the throat and the streamlines from this square followed out to the end of the nozzles where they also form a square. The cross-section shapes of the nozzle between the throat and end section are curved (probably resulting in fabrication difficulties). Contours for a $M = 10$ nozzle without boundary-layer corrections are presented. P. A. Libby, USA

984. Drake, R. M., Jr., and Backer, G. H., Heat transfer from spheres to a rarefied gas in supersonic flow, *Trans. ASME* **74**, 7, 1241–1249, Oct. 1952.

See AMR **5**, Rev. 802.

985. Picard, C., Calculation by linearized supersonic flow theory of hinge moments of controls of a rectilinear wing (in French), *Rech. aéro.* no. 28, 3–11, July/Aug. 1952.

The linearized-theory pressure distributions on rectangular wings equipped with various arrangements of rectangular flaps (including both the leading-edge and trailing-edge varieties) are integrated to obtain expressions for the total lift, pitching moment, and hinge moment. Some of these results are also presented in graphical form, together with appropriate experimental data. John R. Spreiter, USA

986. Fitzpatrick, J. E., and Schneider, W. C., Effects of Mach number variation between 0.07 and 0.34 and Reynolds number variation between 0.97 × 10⁶ and 8.10 × 10⁶ on the maximum lift coefficient of a wing of NACA 64-210 airfoil sections, *NACA* 2753, 34 pp., Aug. 1952.

The effects of Mach number and Reynolds number on the maximum lift coefficient of a wing of NACA 64-210 airfoil sections are presented. The wing was tested through the speed range of the Langley 19-ft pressure tunnel at two values of air pressure. The ranges of Mach number obtained were from 0.07 to 0.34 at atmospheric pressure and from 0.08 to 0.26 at a pressure of 33 psia. The corresponding Reynolds number ranges were from 0.97×10^6 to 4.44×10^6 and from 2.20×10^6 to 8.10×10^6, respectively. The tests were made with and without partial-span and full-span split flaps deflected 60°. Pressure-distribution measurements were obtained for all configurations. The maximum lift coefficient was a function of the two independent variables, Mach number and Reynolds number, and both parameters had an important effect on the maximum lift coefficient in the ranges investigated. The stall-progression and, consequently, the shape of the lift-curve at the stall were influenced by variations in both Mach number and Reynolds number. Peak maximum lift coefficients were measured at Mach numbers between 0.12 and 0.20, depending on the Reynolds number range and flap configuration. There was very little influence of either Mach number or Reynolds number on the maximum lift of the wing with leading-edge roughness. From authors' summary

987. Spreiter, J. R., On slender wing-body theory, *J. aero. Sci.* **19**, 8, 571–572, Aug. 1952.

The familiar linearized form of the partial differential equation governing fluid flow (Prandtl-Glauert equation) is based on the assumption that the magnitude of the ratio of the local perturbation velocity to the free-stream velocity is much less than one. This assumption implies nothing as to the relative magnitudes of the perturbation-velocity components. Hence, the correctly ordered expression for pressure coefficient (difference between local and free-stream pressure divided by free-stream dynamic pressure) is

$$C_p = -(2u/U_0) - (v/U_0)^2 - (w/U_0)^2 \qquad [a]$$

where U_0 is the free-stream speed, and u, v, and w are local perturbation-velocity components derived on the basis of the Prandtl-Glauert equation.

The squared terms in Eq. [a] very often can be neglected, as in studies devoted to the calculation of forces on ordinary plane wings. In certain cases, however, such as those involving slender wing-body combinations or slender cruciform wings, they can be important. Their inclusion makes it impossible to separate angle of attack from thickness effects in the calculation of pressures. Author points out that by placing both the angle of attack and thickness solutions for the induced velocities about a triangular wing mounted on a conical body into Eq. [a], and integrating the result over the wing and body, the lift so obtained is in complete agreement with that found by momentum considerations and given by Ward [see AMR **3**, Rev. 529]. H. Lomax, USA

988. Heaslet, M. A., and Spreiter, J. R., Reciprocity relations in aerodynamics, *NACA TN* 2700, 38 pp., May 1952.

Paper is the result of an effort to develop in a generalized

manner the reciprocity relations which are found in many fields of applied mechanics. Reference is made to some of the earlier work in the theories of elasticity, sound, and dynamics. The present work is primarily concerned with a detailed exactness of such relationships as are found in aerodynamics, including both supersonic and subsonic cases. More of these examples are considered in the field of aerodynamics of wings in both steady and unsteady flow fields.

M. J. Thompson, USA

989. **Cohen, Doris, Formulas for the supersonic loading, lift and drag of flat swept-back wings with leading edges behind the Mach lines,** *NACA Rep.* 1050, 40 pp., 1951.

The method of superposition of linearized conical fields is applied to determine the supersonic flow past each of a series of flat, sweptback, tapered wings with rectilinear boundaries and tips parallel to the undisturbed stream. The wing-leading edges must lie within the Mach cone at the nose, but the trailing edges may lie outside the Mach cone with vertex at the rear edge of the central chord. Formulas for pressure, lift, and drag are derived in each case, and corresponding graphs are drawn for a range of Mach numbers and angles of sweepback. Particular attention is given to corrections at the leading and trailing edges and at the tips. Results are compared with those obtained from a corrected two-dimensional theory; agreement is good in most cases.

Maurice Holt, England

990. **Diederich, F. W., A simple approximate method for calculating spanwise lift distributions and aerodynamic influence coefficients at subsonic speeds,** *NACA TN* 2751, 63 pp., Aug. 1952.

Several approximate methods for calculating lift distributions at subsonic speeds are combined and extended to form a simple step-by-step procedure for calculating symmetric and antisymmetric lift distributions for arbitrary angle-of-attack conditions on swept and unswept wings. Methods of estimating the required aerodynamic characteristics are included, but any available theoretical or experimental results may be used in several steps of the analysis to shorten the work and increase the accuracy. The extension of the method to the calculation of aerodynamic influence coefficients and of spanwise moment distributions is indicated.

The results obtained by the method compare favorably with those obtained by more time-consuming theories.

From author's summary by Tore Gullstrand, Sweden

991. **Radok, J. R. M., The asymptotic behavior of the indicial lift function in subsonic compressible flow,** *Nat. LuchtLab. Amsterdam Rap.* F. 106, 6 pp., Sept. 1951.

Author has previously deduced [see AMR **5,** Rev. 1821] approximate formulas, valid at low frequency, for flutter derivatives of airfoils in subsonic compressible flow. Superposition of harmonic solutions is used to represent a step change. Asymptotic approximation for large $s = Vt/l$ is found by using previous low-frequency formulas. Results show Prandtl-Glauert correction is valid for large s.

J. D. Cole, USA

992. **Hasimoto, H., Application of the thin-wing-expansion method to the compressible flow past an elliptic cylinder,** *J. phys. Soc. Japan* **7,** 3, 322–328, May/June 1952.

Imai's thin-wing-expansion method is applied to a uniform flow past an elliptic cylinder at zero angle of attack, in order to obtain the analytic expressions to the third approximation for the complex velocity potential, and for the velocity distribution over the cylinder. Numerical calculation is made for the case $t = 0.1$, where t is the thickness ratio of the cylinder. The convergence of the result seems to be satisfactory except near the stagnation point, where the anomalous behavior appears.

From author's summary by A. R. Mitchell, Scotland

993. **Smoldírev, A. E., Flow of compressed air in inclined pipes** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **81,** 2, 165–166, Nov. 1951.

The equation of motion of compressed air in the general case of inclined pipe is considered in view of applications to pneumatic transport arrangements. When the flow is stationary and isothermal, i.e., $Q = F\rho v = \text{const}$, $T = \text{const}$, the equation of motion is

$$v\,dv/ds = -1/\rho \cdot dp/ds + g \sin \alpha - \lambda/2D \cdot v^2 \qquad [1]$$

(v is mean velocity, s coordinate along the pipe, λ coefficient of resistance, D diameter of pipe, F area of normal cross secton). Taking the boundary condition in the form $s = 0$, $p = p_1$, and performing the integration, we have

$$s\frac{\lambda}{D} = \frac{1}{A}\ln\frac{p^2A - B}{p_1^2A - B} + \ln\frac{p^2(p_1^2A - B)}{p_1^2(p^2A - B)} \qquad [2]$$

with $\qquad A = 2D/\lambda RT \sin \alpha;\ B = RTQ^2/gF^2$

By evaluating the limit when $\alpha \to 0$, one obtains the equation for a horizontal pipe. Because in pneumatic transport arrangements the Mach-numbers are small, the second term on the right of Eq. [2] can be neglected. Thus, simple expressions for Q are deduced in the cases of ascending, descending, and horizontal pipe.

J. Beránek, Czechoslovakia

994. **Stein, N., Elfrink, E. B., Wiener, L. D., and Sandberg, C. R., The slip velocity of gases rising through liquid columns,** *J. Petr. Technol.* **4,** 9 (195), 233–240, Sept. 1952.

Paper presents the results of a study of the slip velocity of gases rising through liquids in vertical tubes, inclined tubes, and vertical annuli. The data were obtained in gas-liquid systems which included combinations of air, propane, and natural gas (over 97% methane) with water, lubricating oils, and crude oils. The 214 data points obtained in this study, along with 11 data points reported in the literature, are incorporated in an empirical correlation which relates the mean slip velocity of gases flowing through liquids with the parameters gas rate, tube size, ratio of liquid viscosity to liquid density, gas density, liquid density, and the angle of the tube from the vertical.

The average numerical deviation of the measured slip-velocity data from values obtained from the correlation is 9.2%. The average algebraic deviation between measured and predicted data is 0.31%, an indication that the correlation is a satisfactory representation of the data.

The correlation presented will be useful primarily in the design of subsurface gas-oil separation equipment for increasing the efficiency of oil-well pumping installations, but may perhaps be extended to other situations of gases rising through liquid columns.

From authors' summary

Turbulence, Boundary Layer, etc.

(See also Revs. 957, 969, 980, 1061)

995. **Baines, W. D., A literature survey of boundary-layer development on smooth and rough surfaces at zero pressure gradient,** State Univ. Iowa, 41 pp., 11 figs., 1951.

A survey has been made on the boundary-layer flow over flat plates, and drag-test results achieved by the author show good agreement with those of other investigators. The subject of

transition is just touched upon. A general relation for turbulent boundary-layer parameters has been deduced for rough and smooth surfaces. A number of formulas contain misleading errors and should, therefore, be applied with caution.

F. W. David, Australia

996. Rothfus, R. R., and Prengle, R. S., Laminar-turbulent transition in smooth tubes, *Indust. Engng. Chem.* **44,** 7, 1683–1688, July 1952.

The transition flow of water in two tubes with long calming sections has been studied by means of dye injection. Permanent turbulence thus became visible first in the center at a Reynolds number (based on the diameter) N_{Re} of about 900. At higher N_{Re}, the thickness of the laminar annulus surrounding the turbulent cove was found to depend on the local velocity at the edge of the annulus, so that an equation could be developed for the thickness of the laminar film depending on N_{Re}. This film disappeared at N_{Re} about 2100. At still higher N_{Re}'s (up to 3500), it was possible to observe laminar motion near the wall, though only for short intervals.

K. Wieghardt, Germany

997. Wuest, W., Boundary layers on cylindrical bodies with nonstationary axial motion (in German), *ZAMM* **32,** 6, 172–178, June 1952.

Three-dimensional nonstationary flows in laminar boundary layers on a cylindrical body with wedge section, as well as on a circular cylinder, are studied. Author studies the case when, at the same time, these cylinders move unsteadily (especially periodically) in the direction of the edge of the wedge or in the direction of the axis of the circular cylinder. As a simple special case of the flow past a wedge, author also discusses the flow in the vicinity of a stagnation point.

S. Tomotika, Japan

998. Maekawa, T., and Atsumi, S., Transition caused by the laminar flow separation, *NACA TM* 1352, 14 pp., Sept. 1952.

Translation of paper reviewed in AMR **2,** Rev. 1306.

999. Pretsch, J., The excitation of unstable perturbations in a laminar friction layer, *NACA TM* 1343, 63 pp., Sept. 1952.

Translation from *Jahrb. deutsch. Luftfahrtforsch.*, Aug. 1942.

1000. Bass, J., On a type of nonhomogeneous turbulent flow (in French), *C. R. Acad. Sci. Paris* **234,** 23, 2256–2257, June 1952.

Previous study of space-time correlations in stationary homogeneous turbulence [AMR **5**, Rev. 2449] is extended to a case of stationary turbulence which is nonhomogeneous along an axis λ, homogeneous in each plane normal to λ, and having λ as an axis of cylindrical symmetry.

F. N. Frenkiel, USA

1001. Batchelor, G. K., The effect of homogeneous turbulence on material lines and surfaces, *Proc. roy. Soc. Lond.* (*A*) **213,** 1114, 349–366, July 1952.

Paper extends author's previous work on general problem of diffusion in a spatially homogeneous turbulent field [Batchelor, G. K., title source, (*A*) **201,** 405, 1950; AMR **5,** Rev. 2426].

Kinematical results are derived for the time rate of increase of length and area for material lines and surfaces (i.e., those consisting of the same fluid particles) following the motion. For initially short lines and small areas, experiencing uniform strain, it is shown that lengths and areas increase exponentially (though at a different rate) with t, for $t - t_0$ sufficiently large.

These results are used to study the time history of an initially specified spatial distribution of a local fluid property of two types; viz., a scalar quantity θ of which the total amount in a material volume remains constant (e.g., mass density of a foreign substance), and a vector **F** whose total flux across a material surface is constant (e.g., vorticity). **F** and **G** $= \Delta\theta$ are proportional to the vector line elements and surface elements, respectively; hence, both increase exponentially with time.

The relative effects of the turbulent convection and combined molecular diffusion on **F** and **G** are compared. Convection is dominant for **F** if the appropriate molecular diffusivity is small compared to the kinematic viscosity, and for **G** if its initial distribution has a large enough length scale.

L. M. Grossman, Holland

1002. Martinot-Lagarde, A., Remarks on the spectrum of turbulence (in French), *Actes Coll. Inter. Mécan.* **III,** *Publ. sci. tech. Min. Air, Paris,* no. 251, 273–280, 1951.

Remarks concern the validity of Fourier transform relations between the frequency spectrum $f(\omega)$ and the correlation coefficient $R(h)$ for the case where, first, our instruments are only sensitive within a finite range of frequencies, and second, the measurements can only be made during a finite time.

One of the consequences is that, since the measured $f_T(0) = 0$, also ${}_0\int^\infty R_T(h)dh$ must be zero, whereas, in general, this integral is not zero.

A provisional definition of stationary turbulence has been given, according to which the experimental $R_{T_e}(h) =$

$$_{t_0-T}\int^{t_0+T} u(t)u(t+h)dt / _{t_0-T}\int^{t_0+T} u^2(t)dt$$

must be independent of t_0 and T with the approximation 2ϵ, provided $-T_0 < t < T_0$ and $2T > 2T_e$. Author explains that turbulence satisfies this condition if the amplitude of vibrations with frequencies of the order $1/2T$ and lower is negligibly small. However, a rigorous proof of the condition ${}_0\int^\infty \{f_T(\omega)/\omega\}d\omega < \epsilon 2T$ is still required.

If for $|h| \geqslant H$, $R_{T_e}(h) \simeq 0$, it is sufficient to take $2T > H/\epsilon$, in which case $R_{T_e}(\omega) \simeq f_T(\omega)$.

The experimental $R_{T_e}(\omega)$ cannot have a discrete value, as, according to the Fourier relation, $R_T(h)$ should contain a periodic term that does not tend to zero, which contradicts experimental evidence.

J. O. Hinze, Holland

1003. Rotta, J., Statistical theory of nonhomogeneous turbulence (in German), *Z. Phys.* **131,** 1, 51–77, 1951.

Author supplements his previous work [see AMR **5,** Rev. 829] with a relation for the variation of the scale of turbulence in space and time. In this way, he obtains a solvable system of equations for the turbulent fluctuations in shear flow. The solution still contains some arbitrary constants. By proper choice of these constants, author finds reasonably good agreement between theory and experiments in the case of pressure flow through a two-dimensional channel.

C. C. Lin, USA

1004. Jousserandot, P., Application to a complete aircraft model of boundary-layer control by blowing on the flaps and ailerons (in French), *Rech. aéro.* no. 23, 13–22, Sept./Oct. 1951.

Paper presents results of wind-tunnel tests on a complete fifth-scale model ME 109. The investigations were concerned with boundary-layer control by means of blowing directly on the ailerons and flaps. The tests were conducted in the ONERA wind tunnel at Cannes which has a closed throat 3 m in diam and a speed of 50 m per sec.

The objective of the boundary-layer control was to provide increased lift for landing together with increased lateral control by preventing flow separation on the ailerons. Typical results showed an increase of lift coefficient from 2.6 without blowing, to 4.6 with blowing.

The increased lift at the trailing edge of the wing caused a

diving moment which had to be counteracted by negative lift on the tail surfaces. This effect decreased to some extent the total lift on the airplane as a whole.

The results were considered sufficiently encouraging that further tests are planned in the larger wind tunnel of Chalais-Meudon on a full-scale model of the SO 6020, with double flaps.

F. L. Wattendorf, USA

1005. **Landis, F., and Shapiro, A. H., The turbulent mixing of co-axial gas jets,** Heat Transfer Fluid Mech. Inst., Stanford Univ., Press, 133–146, 1951. $5.

Tests were conducted with two main objectives in mind: (1) Better understanding of free turbulence and the mechanisms of turbulent diffusion; (2) creation of basis for direct engineering-design applications, such as jet pumps, thrust augmentors, combustion chambers. Speed ranges of circular inner jet and outer jet were 180 to 200 fps and 50 to 135 fps, respectively. Variation of density ratio (inner to outer) was 0.6 to 1.0, and velocity ratio (outer to inner) 0.25 to 0.75. Inner jet diameter was $^1/_2$ to 1 in.

The main conclusions of authors are: (1) Comparison between different types of turbulent transfer can only be valid on the end of the "potential core." (2) In the developed flow region, the fully normalized shapes of velocity temperature and concentration profiles are substantially alike. (3) Velocity ratio is the primary variable; density ratio and absolute velocity have a lesser effect. (4) The frequently observed faster transfer of temperature than that of mass is essentially due to heat transfer across the tail-pipe walls. Authors believe that, in the ideal case of flat initial profiles and no heat flux through walls, mass and temperature will spread alike. (5) The "turbulent" Prandtl and Schmidt numbers are both $\approx$ 0.7. (6) Comparison of results with other theoretical and experimental investigations suggests that conclusions can be extended without serious error to compressible flow and large density differences. In addition, empirical terms for both velocity and temperature profiles and the decay along the center line are given, and comparisons are made with theoretical work by Squire and Trouncer and others.

Paper gives an excellent survey on the problem in very concise form. References of the most important investigations on the subject are quoted.

H. J. Ramm, USA

1006. **Mager, A., Generalization of boundary-layer momentum-integral equations to three-dimensional flows including those of rotating system,** *NACA Rep.* 1067, 16 pp., 1952.

See AMR 4, Rev. 3944.

1007. **Eckert, E. R. G., and Livingood, J. N. B., Method for calculation of heat transfer in laminar region of air flow around cylinders of arbitrary cross section (including large temperature differences and transpiration cooling),** *NACA TN* 2733, 71 pp., June 1952.

An approximate method is developed for calculating local heat transfer in the laminar boundary layer of air flow around cylinders, using available exact solutions of boundary-layer equations for incompressible wedge flow around wedge profiles. This previously developed wedge-flow technique is extended to include large temperature differences between cylinder wall and flow, and porous-surface transpiration cooling with main-flow cooling medium, as well as high flow velocities, temperature-dependent properties, and arbitrary cylinder profiles. Charts prepared from exact wedge solutions encompassing these effects are presented for rapid calculation of cylinder flow from either the thermal or convection boundary-layer thickness. Local heat-transfer coefficients for special case of nonporous circular cylinder are shown to agree within 5% with exact calculation and within 8% with experiment. Increased generality of extended wedge-flow method is principal contribution of report, although but few corresponding exact wedge solutions are available. Report also includes valuable history and bibliography.

P. J. Schneider, USA

1008. **Krzywoblocki, M. Z. V., On the equations of the decay of isotropic turbulence in compressible fluid,** *J. phys. Soc. Japan* **7**, 3, 299–300, May/June 1952.

On the basis of his previous works, author derives the equations of the decay of turbulence in a compressible fluid. All the random variables, like the velocity components, density, temperature, pressure, etc., fulfill the requirements of isotropy and homogeneity and are dependent. The derived equations represent the decay of velocity, temperature, and density, or pressure fluctuations, respectively.

From author's summary by T. P. Torda, USA

1009. **Sato, H., Experimental study of the spectrum of isotropic turbulence, II,** *J. phys. Soc. Japan* **7**, 4, 392–396, July/Aug. 1952.

In the isotropic turbulent field, energy spectrum was observed by an improved equipment. The measurements were made in a closed channel which was added to the exit cone of an open-type wind tunnel. A voltage integrator was used to read the fluctuating output of low-frequency components. Low-cut filter attached to the input terminal increased the accuracy at high-frequency region.

Measured spectrum curves are nearly the same as previously reported [AMR 5, Rev. 1837]. The decay of spectral components is severer at high wave number throughout decay process. The energy transition is estimated from the measurements abovementioned. The wave number of zero transition decreases as the turbulence decays. Finally, the gradient of spectrum curve is determined by differentiating the spectrum with respect to wind speed. At medium wave-number region, the power index is about $-5/3$. Three-dimensional spectrum is also obtained by this method.

From author's summary

1010. **Bass, J., The total correlation function and its application to the Kármán equation** (in French), *Actes Coll. Inter. Mécan.* **III**, *Publ. sci. tech. Min. Air, Paris*, no. 251, 267–271, 1951.

Author points out that there are some analytical advantages in using Agostini's total correlation function as the dependent variable in the dynamical equation for isotropic turbulence.

G. K. Batchelor, England

Aerodynamics of Flight; Wind Forces

(See also Revs. 731, 732, 759, 965, 988, 1028, 1029, 1043, 1048, 1102, 1127)

1011. **Duncan, W. J., The principles of the control and stability of aircraft,** New York, Cambridge Univ. Press, 1952, xvi + 384 pp. $8.

Professor Duncan opens his exposition by saying that "An aircraft is a kind of vehicle and a vehicle is a kind of tool . . . so designed and made that it enables men to do what they could not do with their unaided bodies." Both control and stability are necessary for an aircraft to be a suitable tool, and the volume is concerned with the effect of an aircraft's configuration and changes in configuration upon the forces acting, together with the resultant flight path. Principles for achieving the most desirable distribution of applied, inertial, and local aerodynamic forces are discussed by considering control surfaces, propulsive systems, structural distortion, mass distribution, control-system flexibility,

aircraft geometry, and sundry lesser important factors, which are examined in terms of their effects upon the dimensionless stability derivatives.

The dimensionless derivatives enter into dimensionless forms of the equations of motion which the author establishes. The derivation of the equations, although necessarily lengthy and involved, is performed systematically and forms a firm mathematical basis, not too advanced for the practicing engineer, to which the detailed discussions are related. The significance of the independence of longitudinal and lateral motions receives some attention, as does possible coupling, and independent equations for each motion are written explicitly. Solutions of the equations are indicated, and criteria for stable solutions are discussed in detail, as well as the expression of the criteria in terms of the derivatives. The interrelationship of aircraft control, static stability, and dynamic stability is lucidly presented, and the importance of neutral and maneuver points is stressed.

Full use is made of thin-airfoil theory, experimental data, and physical arguments to make the subject matter more readily comprehensible. Simplifying assumptions are discussed and their limitations indicated wherever possible. A chapter is devoted to experimental determination of the derivatives, another to compressibility effects, while other high-speed flight problems are treated briefly. Professor A. D. Young contributed two chapters: "Stalling and the spin" and "Flaps for landing and take-off."

As the title indicates, the volume deals with the principles involved, with the result that many details are omitted. This is partially compensated for by citing 34 general references and 48 references to detailed investigations of a specific nature. This able and scholarly dissertation pleases the reviewer, who feels that the present work will become as widely studied and referenced as a previous Cambridge publication by Glauert, which was somewhat too early to be a part of the new Cambridge Aeronautical Series. T. F. O'Brien, USA

1012. Jaquet, B. M., Effect of linear spanwise variations of twist and circular-arc camber on low-speed static stability, rolling, and yawing characteristics of a 45° sweptback wing of aspect ratio 4 and taper ratio 0.6, *NACA TN* **2775, 27 pp., Aug. 1952.**

Results of the investigation indicate that twist or camber produced only small changes in the maximum lift coefficient. A combination of camber and twist was more effective than twist alone in providing an increase in the maximum lift-to-drag ratio in the moderate lift-coefficient range for the wings investigated. The variation of static longitudinal stability through the lift-coefficient range was less for the twisted wing than for the twisted and cambered or plane wing.

A combination of twist and camber generally extended the initial linear range of several of the static- and rotary-stability derivatives to a higher lift coefficient and, although these effects were small, higher Reynolds numbers may result in larger effects. From author's summary

1013. Schade, R. O., Gates, O. B., Jr., and Hassell, J. L., Jr., The effects on dynamic lateral stability and controllability of large artificial variations in the rotary stability derivatives, *J. aero. Sci.* **19, 9, 601–608, Sept. 1952.**

See AMR 5, Rev. 2690.

1014. Gatland, K. W., Development of the guided missile, London, Iliffe & Sons, Ltd.; New York, Philosophical Library, 1952, x + 133 pp. $3.75.

Book is a revised compilation of a series of magazine articles which previously appeared (1951) in *Flight* (British journal). In addition to the chronological data and pertinent facts, gathered largely from American and German sources, which outline the development of the guided missile, the book contains a generous sprinkling of editorial comment regarding the "defences" of the British Isles and the security policies of the British Government. Author also spends some time considering future as well as past development, and offers many suggestions for the improvement and evolution of guided missiles.

Technically speaking, the book is concerned primarily with the performance and the propulsive systems of various types of missiles, including high-altitude research rockets, space-satellite and interplanetary-flight vehicles, and, of course, missiles intended for military combat. Means of automatic control and guidance are discussed sufficiently to be of interest to amateur scientists or professionals in other fields. Among the interesting contributions are the photographic data and the appendix containing a tabular compilation of facts and figures for 90 significant powered missiles. Arthur L. Jones, USA

1015. Houbolt, J. C., and Kordes, E. E., Gust-response analysis of an airplane including wing bending flexibility, *NACA TN* **2763, 48 pp., Sept. 1952.**

A simplified analysis is presented in two degrees of freedom—vertical rigid-body motion and displacement of the fundamental bending vibration mode of the wing. Unsteady-lift growth expressions for incompressible flow based on the midspan chord of the wing are used. The equations are solved by a finite difference numerical integration method making use of matrix notation. The method may be used to solve the inverse problem of finding the gust shape causing a given response, and to find the response of one airplane from the known response of another airplane to the same gust. An example calculation is performed, yielding results in good agreement with results from a more precise but more lengthy method. Gabriel Isakson, USA

1016. Curtis, A. R., Note on the application of Thwaites' numerical method for the design of cambered aerofoils, *Aero. Res. Counc. Lond. Rep. Mem.* **2665, 13 pp., Feb. 1949, published 1952.**

Some developments in the application of Thwaites' method for the design of low-drag airfoil section are described [*Rep. Mem.* 2166 and 2167, 1945]. A complete set of tables for a 20-point calculation is added. N. Scholz, Germany

1017. Khalil, K. H., Rotational effects on a cascade of aerofoil blades, *Engineer, Lond.* **193, 5030, 831–834, June 1952.**

In rotation, the flow in the blade passage behaves differently from that of a fixed cascade because of the centrifugal action. In view of this, a cascade of aerofoil blades was rotated in a wind tunnel. Pressure-distribution diagrams around the blade section were obtained at various angles of incidence by changing the components of flow, the axial wind velocity, and the rotation. The resultant velocity was kept constant. The pitch and the number of blades were changed. The product of pitch and number was kept constant. At the same angle of incidence, the pressure distribution of a blade shows a reduction of the suction on the back as the number of blades increases. The effective force of a blade decreases with increasing number of blades. But the total forces on all blades of the cascade together shows a maximum when the cascade has twelve blades. The rotating cascade was compared with a fixed cascade at the same pitches and incidences. The circulation of the blades is diminished by rotation. This effect of rotation increases with the number of blades. With shrouding, the pressure-distribution diagrams show changes near the leading edge, while pressures near the trailing edges are not affected. A. Betz, Germany

1018. **Rogallo, V. L., Effects of wing sweep on the upwash at the propeller planes of multiengine airplanes,** *NACA TN* 2795, 46 pp., Sept. 1952.

An analysis is presented to give a qualitative picture of the effects of wing sweep on the upwash at the propeller planes of multiengine airplanes. In order to provide a basis for judging effects of sweep, comparisons are made of the upwash and upflow angles at the propeller planes of two hypothetical airplanes of the high-speed long-range type, one having an unswept wing and the other a sweptback wing. The effects of compressibility are considered. Charts are provided to enable the prediction of upwash in the chord-plane region ahead of wings of various planforms.

From author's summary by H. P. Liepman, USA

1019. **Yates, A. H., Manoeuvrability at high speeds,** *Aircr. Engng.* **24**, 282, 228–230, Aug. 1952.

The speed and normal acceleration range of modern fighters are limited severely at high altitudes by the stall and buffet boundaries. The author assumes a $C_{L_{max}}$ curve and a 0.9 Mach number limit to calculate maneuverability in terms of g's available at various heights. The increase in drag in the turn can be calculated to determine the allowable speed-g range for the turbojet engine. With these limits, the tactical capabilities can be determined from a diagram of rate of turn vs. speed for various radii and normal accelerations. F. W. Heilenday, USA

1020. **Taylor, A. S., Manoeuvre point properties of the aero-isoclinic wing,** *Aircr. Engng.* **24**, 283, 257–262, Sept. 1952.

A detailed examination was made of high-speed aeroelastic effects on maneuver point of an aero-isoclinic wing (one which, under the combined bending and twisting effects of air loads acting along the aerodynamic axis, exhibits no change in local incidence at any spanwise station), with special reference to the effect of rearward movement of local aerodynamic centers at supercritical Mach numbers. From the results of calculations, using the method of *R.A.E. Rep. No. Aero.* 2320, it is concluded that, as regards possible shifts of maneuver point, the aero-isoclinic wing is generally superior to the conventional wing.

For tailless aircraft, application of the aero-isoclinic principle makes it possible to employ wings of an aspect ratio much larger than is considered practicable with conventional design. Structural design of a flutter-free aero-isoclinic wing entails radical departures from orthodox procedure, and with tailed aircraft it is, therefore, probably preferable to adapt the design of the tail plane and its attachment to cope with the destabilizing deformability effect of a conventional wing, than to eradicate such effects at the source by aero-isoclinic design of the wing.

From author's summary by F. W. Diederich, USA

1021. **Couchet, G., Existence of nonstationary plane motion of a wing on which no aerodynamic forces are acting** (in French), *Rech. aéro.* no. 28, 13–15, July/Aug. 1952.

Referring to a previous publication [see AMR **3**, Rev. 1308], author gives a decomposition of aerodynamic stresses for a wing in nonstationary motion with constant circulation, showing the motions in which the aerodynamic forces do not act. An application of results to the control problem is promised.

A. van Heemert, Holland

1022. **Newbigin, H. G., Development of the Ambassador de-icing system,** *Aircr. Engng.* **24**, 282, 216–220, Aug. 1952.

Author discusses problems encountered in developing a thermal ice-prevention system. Included are problems associated with combustion heaters, temperature-measuring instrumentation, heated air-intakes, propeller and windshield deicing, and flight testing in natural icing conditions. Article reveals that American definitions of icing severity are adopted, in part, as criteria for specification of heat intensities required for protection. Author's report, however, of heat intensities actually found to be adequate in flight cannot be appraised for lack of information concerning air speed. Article is nontechnical, and interestingly emphasizes the difficult road that must be followed after conceiving a design until it is realized in a form suitable for public use.

N. R. Bergrun, USA

1023. **Fedyaevskiĭ, K. K., Approximate theoretical determination of apparent additional mass of rectangular plates** (in Russian), *Prikl. Mat. Mekh.* **16**, 3, 352–354, May/June 1952.

The difference between coefficients of transverse and longitudinal additional apparent mass, which enters into the expression for the pitching moment of a flat rectangular plate of finite aspect ratio λ moving with a constant speed V at an angle of attack α, is approximately determined. Guided by the infinite aspect-ratio case, author replaces the vorticity distributed over the plate by an "equivalent" rectangular concentrated vortex. The boundary conditions on the induced velocity are satisfied only at four symmetrically located points on the plate; the spanwise location z of these points is apparently chosen by comparison with the results of oscillation-type experiments by Riman and Kreps [*TSAGI* Rep. no. 635, 1947]. From the gratifying agreement between his results and the experiments over the range $1 \leqslant \lambda \leqslant 8$, author concludes that the rectangular vortex can be used for determination of integral characteristics of the flat plate. M. V. Morkovin, USA

1024. **Weissinger, J., Lift distribution on wings with discontinuous spanwise chord distributions** (in German), *Ing.-Arch.* **20**, 3, 166–169, 1952.

The methods generally used for solving the Prandtl lifting-line equation for the spanwise circulation distribution in steady-state converge very slowly in the case of a discontinuity of the distribution of angle of attack over the wing span. Multhopp developed a method which eliminates this undesirable feature by "separation" of the discontinuity and representing the total circulation distribution of the wing by a sum of two circulation distributions satisfying certain boundary conditions at the point of discontinuity. It is not possible to apply the Multhopp method also to the related case of a discontinuity in the chord distribution of the wing. The objective of paper is to show that the Multhopp method may be modified to also cover the case of a chordwise discontinuity, and even the more complex case where the distribution of angle of attack and the distribution of chord over the wing span contain discontinuities. It is found that the amount of computational labor involved in this procedure is reasonable. M. Dengler, USA

1025. **Weissinger, J., On the insertion of additional points in the Multhopp method** (in German), *Ing.-Arch.* **20**, 3, 163–165, 1952.

According to the lifting-line theory of Prandtl, the spanwise circulation distribution over a wing in steady state may be found by solving a certain integral equation. As is well known, this equation may be solved by means of the Trefftz-Glauert method (method 1) or by the Multhopp method (method 2). Both procedures have in common that an approximation of the desired circulation distribution is deduced in the form of a sine-polynomial $P(\vartheta)$ of order m, which requires the solution of a system of linear equations of order m. If ϑ defines the wing station, the difference between the two methods consists in the fact that Trefftz and Glauert make use of the hypothesis $P(\vartheta) = \sum_{n=1}^{m} a_n$

$\cdot \sin n\vartheta$, where the coefficients a_n are to be found, while Multhopp starts out with $P(\vartheta) = (2/(m+1)) \Sigma_{n=1}^{m} \gamma_n \Sigma_{\mu=1}^{m} \sin \mu\vartheta_n \sin \mu\vartheta$, and considers the γ_n as the unknowns which are to be found.

There is, however, another closely related difference: While method 1 may use any wing stations ϑ_n, method 2 requires that the wing stations ϑ_n be defined by $\vartheta_n = n \cdot \pi/(m+1)$. If now the chord distribution $c(\vartheta)$ on the wing is discontinuous, method 1 may easily introduce a few more wing points close to the point of discontinuity to induce higher accuracy of the solution, while method 2 basically is forced to double the whole number of wing points if only one more point is wanted. The purpose of the present study is to show that this difficulty, which would be very undesirable from the standpoint of numerical labor, can be eliminated to a certain extent, and that it is always possible to introduce one single further point into the analysis without increasing substantially the necessary amount of numerical calculation.

M. Dengler, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 991)

1026. Kinnaman, E. B., Flutter analysis of complex airplanes by experimental methods, *J. aero. Sci.* **19**, 9, 577–584, Sept. 1952.

See AMR **5**, Rev. 2146.

1027. Nilsson, E., Blade flutter in turbomachines (in Swedish), *Tekn. Tidskr.* **82**, 34, 761–764, Sept. 1952.

Author gives a brief history of the flutter problem in general, and mentions in particular that a different type of flutter occurs near the stall angle, where an additional phase shift seems to occur between a vibratory motion and the resulting aerodynamic force. He states that the latter type of flutter usually occurs in the blades of axial-flow compressors. A very brief account is given of an approximate theory, and the results of a numerical example are related.

N. O. Myklestad, USA

1028. Foss, K. A., and Diederich, F. W., Charts and approximate formulas for the estimation of aeroelastic effects on the lateral control of swept and unswept wings, *NACA TN* 2747, 70 pp., July 1952.

Charts and approximate formulas are presented for estimating static aeroelastic effects on the spanwise lift distribution, rolling-moment coefficient, and rate-of-roll due to the deflection of ailerons on swept and unswept wings at subsonic and supersonic speeds. Two types of stiffness distributions are considered, one which consists of a variation of stiffness with the fourth power of the chord, and one which is based on an idealized constant-stress structure. Some design considerations brought out by the results of this paper are discussed. Paper treats the lateral-control case in a manner similar to that employed in *NACA TN* 2608 for the symmetric-flight case and is intended to be used in conjunction with that paper. Charts and formulas presented can be applied very easily and with a minimum of additional calculation.

From authors' summary by J. H. Greidanus, Holland

1029. Diederich, F. W., and Foss, K. A., Charts and approximate formulas for the estimation of aeroelastic effects on the loading of swept and unswept wings, *NACA TN* 2608, 98 pp., Feb. 1952.

Charts and approximate formulas are presented for estimating aeroelastic effects on the spanwise-lift distribution, lift-curve slope, aerodynamic center, and damping-in-roll of swept and unswept wings at subsonic and supersonic speeds. Two types of stiffness distributions are considered: one which consists of a variation of the stiffness with the fourth power of the chord, and one which is based on an idealized constant-stress structure. Some design considerations brought out by the results of this paper are discussed.

From authors' summary by J. E. Stevens, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 950, 1018, 1027, 1034, 1082, 1086)

1030. Lane, F., Optimum single propellers in radially varying, incompressible inflow, *J. appl. Mech.* **19**, 3, 252–256, Sept. 1952.

Paper develops the induced velocity relations for optimum efficiency developed first by Betz and extended by Theodorsen for the case of axially symmetric, nonuniform inflow, such as occurs in the wake of a body of revolution. With a given inflow pattern, thrust requirement, and advance ratio, the optimum induced velocity and bound vortex functions can be determined. Consideration of the blade profile drag fixes the propeller diameter for optimum total energy loss.

Mathematic expressions are given for the generalized thrust and torque of a propeller in terms of the circulation function. Prandtl's approximation for finite numbers of blades is extended and justified in the optimum process. Experimental measurements conducted on a body of 7:1 fineness ratio show no startling disagreements with the theory.

Reviewer believes this method may be useful for performance and design calculations of pusher-type airscrews.

J. B. Duke, USA

1031. MacGregor, C. A., Two-dimensional losses in turbine blades, *J. aero. Sci.* **19**, 6, 404–408, 432, June 1952.

Paper reports tests made on three turbine cascades of varying angle of attack, stagger angle, and for a downstream Mach number of 0.4 and a Reynolds number of 6.5×10^6. A formula is also derived for the computation of a blade-loss factor from the cascade geometry, and the momentum thickness and the ratio of momentum thickness to energy thickness of the boundary layer at the trailing edge of the blade. This formula is different from the one given by L. G. Loitsianskiĭ [AMR **3**, Rev. 942].

Based on the measured pressure distribution around the blade, the computed values of the momentum thickness agree closely with the measured values, and the computed values of the loss factor are, in some cases, lower than the measured ones.

C. H. Wu, USA

1032. Soo, S.-L., Wet compression in an axial-flow compressor, *Trans. ASME* **74**, 5, 879–886, July 1592.

The problem of wet compression in an axial-flow compressor is studied, considering heat and mass transfer. The basic relation between the rate of compression, size of water particles, and over-all pressure ratio is obtained. The design criterion of an axial-flow compressor for wet compression is outlined. The possibility of introducing wet compression in a supersonic compressor is investigated as a two-phase Riemann shock problem.

From author's summary by Paul Torda, USA

1033. Shchapov, N. M., Determination of the error in the efficiency of a water turbine in tests (in Russian), *Gidrotekh. Stroit.* no. 6, 30–32, June 1952.

Author develops a numerical method for estimating the accuracy of the efficiency of water turbines as obtained in tests, the rate of flow in the head race of rectangular cross section being measured by a water-measuring vane.

From the analysis, it follows that those measurements and readings which give relatively small figures in each test, have to be made especially carefully. Measurement by means of a water-measuring vane can contribute only a relatively small error, since by this method the velocities in several points of the head race are measured. With careful execution and a sufficiently large number of measuring stations, the water-measuring vane method gives better accuracy than other methods in which the rate of flow is determined by one single measurement (weir, salt-velocity method, pressure-rise method, etc.).

M. Strscheletzky, Germany

Flow and Flight Test Techniques

(See also Revs. 905, 937, 941, 950, 983, 1005, 1026)

1034. **Keast, F. H., High-speed cascade testing techniques,** *Trans. ASME* **74,** 5, 685–691, July 1952.

Paper describes a small blown cascade wind tunnel used since 1948. The boundary layer is controlled by injecting air through slots immediately upstream of the cascade. Automatic integrating yaw and total head equipment, and a wedge-shaped probe are described. A method of analysis which converts cascade results into turbine-performance charts is presented. Some results, using a punched-card method of calculation, are presented.

A. F. W. Langford, Australia

1035. **Lindsey, W. F., Choking of a subsonic induction tunnel by the flow from an induction nozzle,** *NACA TN* 2730, 20 pp., July 1952.

With the induction nozzle just downstream of the working section, it has been found experimentally that, for induction jet pressures greater than a certain value, the Mach number in the working section decreases with increase in induction jet pressure. This is readily demonstrated to be due to choking of the induced flow by the flow from the induction nozzle, and a simple analysis is presented to illustrate the more important parameters involved. It is suggested that, by the use of a main induction nozzle situated along the diffuser and a subsidiary nozzle just downstream of the working section, the choking properties of the latter could be exploited as a means for controlling the speed of the tunnel. The analysis does not consider the power factors involved.

A. D. Young, England

1036. **Ruptash, J., Supersonic wind tunnels—theory, design and performance,** *Inst. Aerophys. Univ. Toronto, UTIA Rev.* no. 5, 175 pp., June 1952.

The paper in outline is: (1) Supersonic wind tunnels—discusses generally their power requirements, cooling problems, effects of humidity, and air condensation. This is followed by a description of the various types of supersonic tunnels and their advantages and disadvantages. (2) Fundamental theoretical equations—gives the equation of state of a gas, the different forms of the energy equation, the isentropic flow relations, the equations for the normal shock and for the oblique shock, and for the reflection of a shock from a wall. A section of 20 pages is devoted to the method of characteristics. (3) Flow in a Laval nozzle—describes the flow and gives the flow relations and a discussion of the change in flow with change in back pressure. (4) Turbulent boundary layer in compressible flow—develops the formulas for calculating the thickness of the turbulent boundary layer on an insulated plate in two-dimensional flow. Formulas for calculating the boundary-layer thickness on the side wall of a divergent supersonic channel are also derived. The development is based on the momentum equation. (5) Two-dimensional supersonic nozzle design—treats graphical methods, semigraphical methods, analytical methods, nozzle contours with continuous wall curvature, nozzle lengths, and the correction of the nozzle contour for boundary-layer effects. (6) Supersonic diffusers—discusses the various types of supersonic diffusers, the minimum throat area required to establish supersonic flow, variable throat diffusers and flow stability, fixed-geometry and variable-geometry supersonic diffusers, multiple-shock-wedge type convergent-divergent supersonic diffusers, and is completed by a section on diffuser efficiency. (7) The final section of the paper gives equations and charts for the test-section flow parameters, a discussion of the minimum pressure ratio to maintain supersonic flow, and is completed by sections showing how to calculate the running time for intermittent-flow supersonic tunnels with vacuum-storage drive or pressure-storage drive. Short sections are given on the power requirements for a continuous-flow supersonic wind tunnel and on the compressor volume required. The paper contains 122 references.

Reviewer believes this paper should be useful to anyone connected with the design or operation of a supersonic wind tunnel.

Neal Tetervin, USA

1037. **Markovitz, H., Yavorsky, P. M., Harper, R. C., Jr., Lapas, L. J., and DeWitt, T. W., Instrument for measuring dynamic viscosities and rigidities,** *Rev. sci. Instrum.* **23,** 8, 430–437, Aug. 1952.

An instrument is described for measuring the dynamic rheological properties of viscoelastic liquids and solids. The design of this instrument is based on that of Goldberg and Sandvik, but differs from theirs in that it is not limited to use at a point of resonance. Examples are given of results obtained by its use on a Newtonian liquid, a viscoelastic liquid, and a viscoelastic solid. A derivation of the equation governing the instrument when used for solids is given in an appendix.

From authors' summary

1038. **Kuss, E., High pressure investigations II: Viscosity of compressed gases** (in German), *Z. angew. Phys.* **4,** 6, 203–207, June 1952.

A new capillary viscosimeter is described for investigation of liquids and gases of very small viscosity; the reproducibility is of a few per mille.

The viscosity of hydrogen at 25, 50, and 75 C, and of methane at 20, 40, 60, and 80° up to 600 atm has been investigated by this method.

From author's summary

1039. **Tissot, M., Use of visualizable perturbation in aerodynamics** (in French), *Actes Coll. Inter. Mécan.* **III,** *Publ. sci. tech. Min. Air, Paris,* no. 251, 133–153, 1951.

The possibility of determining an aerodynamic field by photographing the development of an externally applied infinitesimal perturbation field has been investigated theoretically. Huygen's principle is assumed to govern the evolution of the perturbation wave. It is shown that, if the perturbation wave is a shock, the field quantities can be specified only at the shock front. If ultrasonic waves are used, the entire field can be determined in principle. Reviewer believes that these conclusions are largely of academic interest, at least for the present, since the accuracy required in the various measurements is very difficult to achieve. This point is not treated in the paper. Both weak shocks and ultrasonic waves have been used as perturbations in attempts to investigate very simple aerodynamic fields, but in each case sufficient accuracy was not obtained to recommend the method for general aerodynamic use.

R. E. Duff, USA

1040. Hargest, T. J , An electric tank for the determination of theoretical velocity distributions, *Aero. Res. Counc. Lond. Rep. Mem.* 2699, 9 pp., Apr. 1949, published 1952.

An analogy due to Relf has been applied to the design of apparatus for quickly determining the theoretical velocity distributions around an airfoil in cascade.

The accuracy of the apparatus was tested by determining the velocity distribution around a cylinder. An accuracy of within 1% of the approach velocity was obtained for this case. The apparatus has since been applied to determine the theoretical velocity distribution around various airfoils in cascades; an example is given of the pressure distribution around an airfoil at zero incidence. An application to determine the theoretical velocity distribution around the central airfoil of a nozzle cascade, where the effect of the ducting side walls is included, is also given.

From author's summary

1041. Schmidt, R., Methods of measuring thrust and drag of jet-propelled airplanes in flight and of their models in tunnels (in Spanish), *Cienc. y Técn.* 118, 600, 227–247, June 1952.

The physical nature of thrust and drag is analyzed and discussed. A review is given of the methods which are useful to determine these forces and the conditions which must be satisfied in order to get sufficient precision.

A. Miele, USA

1042. Whitehead, L. G., Two-dimensional wind tunnel interference, *Aero. Res. Counc. Lond. F.M.* 1451, 18 pp., 9 figs., June 1950.

Report contributes to two-dimensional theory of wind-tunnel-wall interference for zero-incidence bodies of large size relative to tunnel height. Main application is to the use of wall-shape adjustment to remove tunnel-wall interference. Neither compressibility effects nor wake blockage are considered.

H. J. Allen, USA

1043. Khalil, K. H., Wind tunnel investigations on rotating blades of aerofoil section, *Engineer, Lond.* **194**, 5038, 221–223, Aug 1952.

Author compares the pressure diagrams at the same angle of attack for an airfoil tested statically and for the same airfoil rotating as a windmill. He compares the radial distribution of load for the two cases and develops a "spin factor" to account for the differences in circulation at any radial station between the static and rotating case. It is not clear to this reviewer on what basis the equivalency between the static and rotating case was established. Since both the static and rotating blades were untwisted, it is obvious that the induced effects were not the same.

R. M. Crane, USA

1044. Merle, Mlle. M., Study of aerodynamic fields by ultrasonics combined with schlieren optics (in French), *Publ. sci. tech. Min. Air, Paris, NT* 44, 28 pp., 1951.

Paper describes instrumentation of a small wind-tunnel facility providing for generation of a parallel beam of ultrasonic waves perpendicular to flow direction, and for recording wave pattern by schlieren optics. Inclination of beam determines Mach number, the observed wave length for known frequency of wave generation, and the absolute temperature in the flow. Schlieren photographs are reproduced showing sound-wave pattern obtained in flows around simple models. Quantitative work is presented only for wave patterns in empty channel, illustrating a temperature determination and demonstrating that, even if beam axis inclination cannot be measured a priori with sufficient precision, it appears to be in satisfactory agreement with computed Mach number of flow.

F. J. Weyl, USA

Thermodynamics

(See also Rev. 944)

1045. Hall, N. A., and Ibele, W. E., Thermodynamic properties of air, nitrogen and oxygen as imperfect gases, *Univ. Minnesota, Inst. Technol., Engng. Exp. Sta. tech. Pap.* 85, 157 pp., Dec. 1951.

Thermodynamic data presented are compressibility factors, pressures, and the pressure corrections for H, S, C_v, and $(C_p - C_v)$. Temperature (100 R, or saturation -5000 R) and density (0.02–8.0 or 9.0 lb/cu ft) are used as arguments. Included, for same temperature range, are zero pressure values of U, H, S and C_p, and the second and third virial coefficients with their temperature derivatives. Results are developed from the virial equation of state, using recalculated Bird and Statz virial coefficient data based on the Lennard-Jones potential. Data were tested with experimental Joule-Thomson coefficients and sonic velocity data. Temperature-entropy and compressibility factor charts have been prepared and are said to be available from authors. The same data have been developed by the National Bureau of Standards which considered the effect of dissociation. This causes deviation from authors' results at higher temperatures.

William H. Roberts, Jr., USA

1046. Wohl, K., Kapp, N. M., and Gazley, C., The stability of open flames, Third Symp. Combust. Flame Expl. Phenom., Williams & Wilkins, Baltimore, Md., 3–21, 1949. $13.50.

Paper reports on experiments with butane-air combustion from tubes and nozzles at normal temperature and pressure. The burning velocity, penetration distance, and amount of dead space are given for a number of cases of tube flashback with mixtures from 2.2 to 4.6% butane. Nozzle flashback is discussed, and the flow of gas and contour of flame are illustrated. Shadow photographs of laminar blow-off and turbulent blow-off and lift are given and discussed. Data are presented on lift and drop back for a wide range of mixtures.

Thomas Caywood, USA

1047. Markstein, G. H., Nonisotropic propagation of combustion waves, *J. chem. Phys.* **20**, 6, 1051–1052, June 1952.

Author replies briefly to the criticisms of his simplified treatment of preferential diffusion of reactants in curved regions of a combustion wave. He concludes that a decision between opposing views seems to be primarily a matter of further experimentation.

Joseph Kaye, USA

1048. Scheller, K., and Bierlein, J. A., Isothermal combustion under flow conditions, *J. Amer. Rocket Soc.* **22**, 5, 245–251, 287, Sept.–Oct. 1952.

An analysis has been made of rocket engines which convert heat into mechanical energy by means of an isothermal expansion. The basic characteristics of such engines have been derived and compared with conventional rocket engines utilizing adiabatic expansions to obtain thrust. It has been found that, in general, an isothermal expansion is a less desirable work cycle than an adiabatic expansion for the conversion of heat into mechanical energy in jet propulsion devices.

From authors' summary by W. T. Olson, USA

1049. Spalding, D. B., Combustion of liquid fuel in a gas stream I, II, *Fuel* **29**, 2–7, 25–32, 1950.

Paper concerns heterogeneous combustion of liquid hydrocarbons as occurring in diesel engines and gas turbines. In part I, a theory is worked out for predicting the temperature rise and combustion rates from the physical properties of the fuel. This

is, essentially, an extension of the analysis presented by G. Ackermann [*VDI Forschungsheft* **382,** 1937] and is based on a postulated analogy between heat and mass transfer associated with the combustion process. In part II, experiments are described of kerosene burned in air under natural convection conditions, and a broad agreement between experimental and theoretical results is demonstrated.

On the basis of these investigations, some conclusions are derived about the combustion of full sprays as associated with the following sequence of events: (1) Formation of droplet spray; (2) evaporation of droplet and ignition of vapor; (3) heating of droplet core with a simultaneous change of composition due to the evaporation of more volatile fractions; (4) carbon precipitation in the droplet either by cracking or by diffusion from flame; (5) carbon burning if proper conditions are provided for the attainment of its ignition temperature. The effects of turbulence and radiation, and the influence of fuel properties and of total pressure on the combustion rate and, especially, coke formation are discussed. A. K. Oppenheim, USA

1050. **Cederquist, K. N., and Bering, P., Wet combustion. A process for the utilization of peat,** *Acta Polyt.* no. 105, 34 pp., 1952.

Peat has been considered a possible substitute for coal, but no satisfactory method of utilization has been found. This is due to the high water content, 85–95%, of the crude peat, and to the difficulty of removing the water by filtration and pressing. Technical problems, particularly heat transfer, have been serious obstacles in the development of industrial methods. Now it has been found that many of those technical problems can be overcome by a new technique, called wet combustion, the main principle of which is oxidation of wet peat by oxygen or air at a temperature of 170–200 C and a pressure of 15–30 kg/cm². By "burning" 10–20% of the crude solids, enough heat is evolved to raise the temperature of the whole mass to such a level that a reaction takes place by which the filterability of the slurry is increased by a factor of 50–100.

A couple of systems for carrying out this reaction have been designed, and various factors, such as the consumption of oxygen, heat, and rate of reaction as well as different technical problems have been studied both in the laboratory and in a pilot plant. Methods for analyzing the various operations and for calculating the performance of equipment have been developed, the results being condensed into diagrams and nomographs.

Finally, a few applications, particularly gasification, are discussed. From authors' summary

1051. **Ehret, L., Neubert, U., and Hahnemann, H., On the influence of strong sound waves on progressing gas flames in pipes** (in German), *Z. angew. Phys.* **4,** 4, 126–134, Apr. 1952.

Propane-air flames burning in half-open or closed elongated pipes of square or circular cross section were exposed to intense sound field of 5000 cps, introduced at closed end by modified Hartmann oscillator [see Ehret and Hahnemann, *Z. tech. Phys.* **23,** 245, 1942]. Flame shapes and motion were recorded by means of high-speed schlieren spark cinematography [see Neubert, ibid., **24,** 179, 1943]. Gas motion ahead of flame was made visible by using heated wires, but technique failed when sound was not applied.

Sound caused flattening of flame shape, reduction of flame speed, and extinction for large amplitudes, instead of increased speed as expected by authors. Study seems too limited and fragmentary to justify definite conclusions. Reviewer believes unexpected result is due to high frequency, and suspects violent flame distortion and speedup would occur below $\sim$ 300 cps.

Earlier version of paper appeared as Ministry of Supply (Gt. Brit.) (A) Völkenrode, Reports and Translations no. 650, Feb. 1947. G. H. Markstein, USA

1052. **Kitson, F. G., Investigation of the effect of the lenght/diameter ratio of a small-scale combustion chamber on weak flame stability limits,** *Nat. aero. Establ. Canada* LR-34, 4 pp., 4 figs., Aug. 1952.

The scale effect on weak stability limits was studied, using propane as fuel in a small-scale combustion apparatus. The stability of the chambers was tested by determining air/fuel ratio limits at which extinction occurs as a function of total air flow (at constant pressure). In this preliminary investigation, it was found that, in two out of the three chamber diameters studied, the weak stability limits were extended by the greatest amounts when length/diameter ratio of the combustion chamber was approximately 7:1. From author's summary

1053. **Callen, H. B., and Greene, R. F., On a theorem of irreversible thermodynamics,** *Phys. Rev.* (2) **86,** 9, 702–710, June 1952.

Authors show that the mean square deviation of the spontaneously fluctuating extensive parameters of a thermodynamic system in equilibrium is related to the dissipative part of the admittance function which characterizes the irreversible response of the system to the applied forces. Results are obtained for two types of constraints which allow the independent fluctuation of only a single extensive parameter. The theorems are the generalization of the Nyquist electrical noise formula and are the thermodynamic statement of an analogous statistical theorem. R. A. Gross, USA

1054. **Codegone, C., On the flow of compressible fluids in long vertical conduits** (in Italian), *Monogr. Lab. Aero. Politecn. Torino = Atti Accad. Sci. Torino* **86,** 10 pp., 1951–1952.

Author considers long vertical pipe giving solution in closed form for perfect gas, and employs numerical method for condensable vapor. M. J. Goglia, USA

Heat and Mass Transfer

(See also Revs. 911, 984, 1007, 1116)

1055. **Goldenberg, H., and Tranter, C. J., Heat flow in an infinite medium heated by a sphere,** *Brit. J. appl. Phys.* **3,** 9, 296–298, Sept. 1952.

Authors present classical solution by Laplace transformation for one-dimensional transient temperature function $V(r, t)$ in a homogeneous sphere $0 \leq r \leq a$ of constant thermal conductivity K_1 and constant thermal diffusivity k_1, and generating constant and uniform heat for $t > 0$ with $V(r, 0) = 0$. The sphere is embedded in the homogeneous infinite medium $r > a$ where also $V(r > a, 0) = 0$, the medium having thermal properties K_2 and k_2. Only example numerical results for impractical case $K_1 \neq K_2$ and $k_1 = k_2$ are given.

The solution is a generalizing extension of a previous one by first author [AMR **5,** Rev. 528] for the case $K_1 = K_2$ and $k_1 = k_2$, a solution originally presented by Carslaw and Jaeger. P. J. Schneider, USA

1056. **Rozen, A. M., Application of the law of corresponding states to convective heat transfer under pressure** (in Russian), *Zh. tekh. Fiz.* **22,** 6, 1016–1021, June 1952.

Assuming law of corresponding states to hold for reduced coefficients of viscosity, heat conductivity, and reduced specific

heat, and using experimental relations between Nu, Re, and Pr, paper gives graphs of reduced coefficients of heat exchange and heat conductivity as functions of reduced temperature and pressure for various classes of substances. D. ter Haar Scotland

1057. Giulianini, A., Convective diffusion (in Italian), *Termotecnica* **6,** 8, 351–354, Aug. 1952.

Author derives relation between a coefficient of mass transfer and the coefficient of heat transfer by convection.

M. J. Goglia, USA

1058. Senkara, T., A certain particular solution of Fourier's equation for heat conduction applied to reverberatory furnaces (in Polish), *Arch. Mech. stos.* **3,** 2, 157–165, 1951.

General solution of Fourier equation for one of the coordinates is given, when the problem border conditions are defined by an infinite trigonometric series. Results are used in case of infinite thickness of wall with calculation of heat quantity absorbed by the wall when the heat transfer is subjected to the law of organic growth. From author's summary

1059. Clark, S. H., and Kays, W. M., Laminar flow forced convection in long rectangular tubes, Heat Transf. Fluid Mech. Inst., Stanford Univ. Press, 159–173, 1952. $4.

The relaxation method of Southwell is utilized to solve the hydrodynamic and thermal differential equations for laminar flow of an incompressible fluid with constant viscosity and thermal conductivity through long ducts of rectangular and triangular cross section. Boundary conditions of either constant heat input per unit length or constant wall temperature are used. Solutions are presented in the form of minimum limiting Nusselt numbers for any rectangular-tube aspect ratio using both boundary conditions, and for the equilateral triangle section with constant heat input only.

Experimental data with air flow confirm the predictions for one aspect ratio and constant wall temperature. Future tests are promised for other aspect ratio ducts and both boundary conditions. R. E. Street, USA

1060. Akai, S., On the upward transmission of heat in the air of heated room, *Geophys. Mag., Tokyo* **23,** 4, 359–365, May 1952.

An analytical analysis of the air movement due to free convection in a heated room under steady-state conditions. Observed and calculated conditions are in reasonable agreement.

W. L. Sibbitt, USA

1061. Baum, V. A., Investigation of the process of turbulent mixing in a fluid flow (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 2, 201–216, Feb. 1952.

The transport velocity of fluid particles across the main stream in a turbulent flow is much lower than the longitudinal velocity component. The influence of parameters of irregular vortexes in turbulent flow on mixing can be estimated if the real mechanism of flow is substituted by a simplified picture. The influence of molecular diffusion on mixing processes can sometimes be neglected.

Experimental devices and results of turbulent mixing of weak aqueous solutions of hyposulfite in water ($Na_2S_2O_3 + 5H_2O$) through square tubes are described. The concentration c is governed by the equation

$$\partial c/\partial x = \epsilon_T/u_x \cdot \partial^2 c/\partial z^2$$

where ϵ_T is coefficient of turbulent mixing, u_x main velocity component, x and z coordinates along and across the tube axis. An experimental equation for ϵ_T is proposed for Reynolds numbers varying from 5000 to 22,000. A. Kuhelj, Yugoslavia

1062. Szczeniowski, J., Considerations on the efficiency of heat exchangers and their characteristic X (in French), *Chaleur Industrie* **33,** 324, 209–212, July 1952.

The already well-known equations for temperature changes in countercurrent and parallel-flow heat exchangers are repeated, and the utility of the dimensionless number $X = KS/W$ is pointed out. (K is over-all heat-transfer coefficient, S heat-transfer surface, W rate of enthalpy flow with one fluid stream.) For a given ratio of flow rates and heat capacities of the two fluids, the temperature changes are functions of X alone.

R. L. Pigford, USA

1063. Eckert, E. R. G., Temperature distribution in the walls of heat exchangers with noncircular flow passages, Heat Transf. Fluid Mech. Inst., Stanford Univ. Press, 175–186, 1952. $4.

Temperature distributions around the circumference of triangular and rectangular cross-section tubes were calculated and compared with circular tubes with the same Nusselt number, the Nusselt number being based on the hydraulic diameter. The temperature along a side of a triangular passage varied from a minimum at center of side to a maximum at corners. The ratio of temperature at corners to that at middle of a side increased with increasing values of Nu/s^*k^*, where Nu is Nusselt number, s^* is ratio of wall thickness to hydraulic diameter, k^* is ratio of wall thermal conductivity to that of fluid. Experiments were made with tubes externally insulated and heated by electric current flowing axially and cooled by internal air flow. Experimental results confirmed calculated values, although measured corner temperatures for triangular cross sections were higher than calculated values. This difference was attributed to slower increase of heat-transfer coefficients than shearing stress near corners with small angles. Byron E. Short, USA

1064. Kays, W. M., and London, A. L., Convective heat transfer and flow-friction behavior of small cylindrical tubes—circular and rectangular cross sections, *Trans. ASME* **74,** 7, 1179–1189, Oct. 1952.

See AMR **5,** Rev. 2949.

1065. London, A. L., Kays, W. M., and Johnson, D. W., Heat-transfer and flow-friction characteristics of some compact heat-exchanger surfaces, *Trans. ASME* **74,** 7, 1167–1177, Oct. 1952.

See AMR **5,** Rev. 1212.

1066. Rohsenow, W. M., A method of correlating heat-transfer data for surface boiling of liquids, *Trans. ASME* **74,** 6, 969–976, Aug. 1952.

See AMR **5,** Rev. 1879.

1067. Johnson, H. A., and Abou-Sabe, A. H., Heat transfer and pressure drop for turbulent flow of air-water mixtures in a horizontal pipe, *Trans. ASME* **74,** 6, 977–987, Aug. 1952.

Investigators give experimental results concerning static pressure drop and heat transfer in a horizontal pipe for a two-phase air-water system. Measurements were carried out in a 15-ft length of 1-in. 16-gage brass tubing. Flow rates include the range of 1000 to 15,000 lb per hr for the water and 0 to 200 lb per hr for the air. Results are presented in terms of parameters initially proposed by Lockhart and Martinelli. Compressibility, momentum, and phase-change effects along the pipe length are considered negligible. R. A. Gross, USA

1068. **Lee, S.-Y., and Blackburn, J. F., Contributions to hydraulic control. 1 Steady-state axial forces on control-valve pistons,** *Trans. ASME* **74,** 6, 1005–1011, Aug. 1952.

See AMR **5,** Rev. 1116.

1069. **Andreevskiĭ, A. K., Modeling of heat-transfer phenomena in a body with internal heat sources** (in Russian), *Zh. tekh. Fiz.* **22,** 5, 816–825, May 1952.

Heat conduction from a row of circular holes in a solid parallel to the surface is investigated by means of electrical analogy. Reference is made to the rigorous mathematical solution for the thermal resistance in terms of hyperbolic functions, as well as to certain approximate solutions. Results of a series of electric-analog solutions obtained from the potential distribution in a thin aluminum sheet are reported and approximated by a linear formula. The correlation with the rigorous formulation is satisfactory. N. A. Hall, USA

1070. **Vernotte, P., Fundamental aspects of thermokinetics. II** (in French), *Publ. sci. tech. Min. Air, Paris TN* 43, 54 pp., 1951.

The article is the second published by the same author on thermokinetics. It starts with a seven-page discourse entitled "The death of the scientific spirit." The relationship between this racy-styled introduction and the rest of the work is not evident. The main work is in four chapters, the first discussing general problems of thermal flow, the second describing possible experimental methods of thermometry and calorimetry, the third on practical methods of measurement of the thermal conductivity of good conductors, and the fourth on the measurement of conductivity in insulators. The treatment throughout is discursive, reflecting a lecture style, and considerable effort is spent in considering problems associated with transient heat phenomena. In the chapter on heat conductivity of good conductors, a detailed treatment is given on the method in which a wire of the material of interest is heated by an electric current, and also of the method of periodic heating usually associated with the name of Angstrom. The work does not consider measurements at elevated or low temperatures and, curiously enough, does not give any references to other workers in the field. J. G. Daunt, USA

1071. **Chari, K. S., and Kulkarni, B. S., Condensation of saturated vapours. I, II, III,** *J. sci. indust. Res. India* **10A,** 5, 6, 8; 199–207, 244–249, 326–332; May, June, Aug. 1951.

Part I discusses briefly the different types of condensation and presents a critical review of the various theories so far proposed for film-type condensation on vertical tubes. Nusselt's theory, its modifications, the experimental results on condensation and their comparison with the predicted results have been discussed in the light of McAdam's approximations. Limitations of Nusselt's expression and its possible modifications to bring calculated values nearer to the experimental results are indicated.

In part II, heat-transfer mechanism of film condensation on vertical tubes is discussed with special reference to the temperature of the wall, and probable cases have been analyzed with formulations of expressions suitable for design purposes. An attempt is made to indicate the most probable distribution of temperature on the tube wall under normal conditions of steady heat abstraction.

Part III discusses the effect of turbulence in the film and illustrates how the Nusselt film theory, when modified to take into account the turbulence, yields a better prediction for condensation. Analytical and experimental results are given with good agreement at high condensation rates.

From authors' summary by Myron Tribus, USA

1072. **Shoda, T., Experimental studies on natural ventilation,** *Japan Sci. Rev.* **2,** 2, 167–182, Aug. 1951.

Author describes experiments on models of buildings to determine the magnitude of natural ventilation due to (1) temperature effects (gravity), and (2) wind. In addition, he presents the results of an experimental determination of the coefficient of discharge (as a function of Reynolds number) for several shapes of openings, cracks, and gaps which might occur in buildings. Reviewer believes this part of the paper to be its major contribution to the science of ventilation. The means used for measuring the small air-flow quantities is noteworthy. This consisted of a technique of measuring the rate of decrease of the concentration of a small charge of CO_2 in a chamber through which the air flowed. Also, a modification of the Kata thermometer was devised and used. A more complete description of these methods would have been of value to the reader.

Theoretical relations based on Bernoulli's equation are presented. The experimental determination of the neutral zone of several models agrees well with prediction from the theory. Author's experiments roughly substantiate theoretical prediction of wind ventilation of models, but reviewer believes this part of the experimental work is open to question. All of the work described in the paper was done on models. S. Zivi, USA

Acoustics

(See also Rev. 736)

1073. **Meyer, E., and Kuhl, W., Remarks on geometrical room acoustics** (in German), *Acustica* **2,** 2, 77–83, 1952.

Sound, reaching the listener within 50 ms after the direct sound, can be increased by suitably tilting of mirrors of approximately $2m^2$ on the nearby walls, hidden behind a screen. Some theory is given, and results shown for three cases: the opera house at Hamburg, a big hall at Bonn, and the theater at Hannover.

R. Vermeulen, Holland

1074. **Kuhl, W., and Kaiser, H., Absorption of structure-borne sound in building materials without and with sand-filled cavities,** *Acustica* **2,** 4, 179–188, 1952.

The loss factor of bricks and reinforced concrete has been measured as function of frequency and vibration amplitude. The absorption of flexural waves on walls, computed according to the results of these measurements, is 20 to 100 times smaller than the actual absorption of structure-borne sound in buildings, the latter being of the order of 1 to 3 db/m. This absorption has been measured by means of piezoelectric transmitters and pickups for structure-borne sound in the frequency range 150 to 3000 cps.

Using hollow stones filled with sand or other granular substance for walls and floors, this absorption increased by 4 to 6 db/m for middle and high frequencies. This additional damping begins at low frequencies if the cavities are large, if the granular substance has sharp edges, or if a mixture of a hard with a soft substance is used. The acoustic impedance of a closed volume of sand has been measured by means of a vibrometer in order to give a physical explanation of the sand damping. In addition, the damping of short beams with filled cavities of different sizes and the absorption at long walls with filled cavities have been investigated, the results being in good agreement with each other.

From authors' summary

1075. **Cremer, L., Theory of impact sound** (in Swedish), *Tekn. Tidsk.* **80,** 17, 389–394, Apr. 1950.

1076. Fischer, F. A., The absorption cross section of acoustic radiators and groups of radiators (in German), *Akust. Beihefte* no. 1, AB-7–AB8, 1951.

An object, irradiated by a plane sound wave, absorbs some of the incident energy; the absorption cross section is the ratio of absorbed power to incident sound intensity, or, in other words, the cross section of an acoustic "black body" absorbing the same amount of power. Author derives the expression for the absorption cross section of a given radiator in terms of its mechanical resistance. He then applies this expression to the classical problem of a rigid piston vibrating in a baffle. Finally, he shows its connection with Stenzel's "condensation factor."

Author claims to have been the first to adapt the concept of absorption cross section, used in antenna theory, to acoustic problems. This is not correct; even though this concept is not as common as that of scattering cross section, it is by no means a new one, and the absorption cross section has been calculated for certain cases [see, e.g., *J. acoust. Soc. Amer.* **20**, 2, 108–124, Mar. 1948]. M. C. Junger, USA

1077. Rust, H. H., and Drubba, H., Plastic visualization of ultrasonic fields through lowering of the boundary surface energy (in German), *Kolloid Z.* **127**, 1, 38–39, June 1952.

By means of fine aluminum particles, it is possible to get a boundary surface of water-aluminum particles which has a smaller boundary energy than the boundary water-air. This surface serves to visualize the ultrasonic field of a quartz generator of 570 kp/s with a performance of 30 watts for a distance between quartz and surface of 3 cm (near field with characteristic interferences) and 15 cm (surface in the form of steps). Furthermore, the sound field is shown for partial dipping of the quartz with an angle of 10° between wave vector and surface energy.

Margot Herbeck, Germany

1078. Stewart, J. L., and Stewart, E. S., A recording ultrasonic interferometer and its alignment, *J. acoust. Soc. Amer.* **24**, 1, 22–26, Jan. 1952.

Paper presents description of circuit employing rf amplification which converts an ultrasonic interferometer into a sensitive self-recording instrument whose records can be simply analyzed to yield a rapid determination of the attenuation and reflection coefficients of gases at low pressures. The second part is a summary of the sources of error in ultrasonic interferometry, their detection, and their correction. In the third part, some data on the velocity, attenuation, and reflection in helium in the region two to sixty Mc/atoms are presented to illustrate the range, precision, and absolute errors of the instrument.

From authors' summary by S. I. Weiss, USA

1079. Mulders, C. E., Reverberation measurements in liquids, *Atti Conv. Inter. Ultracust.*, 1950; Bologna, N. Zanichelli, 255–259, 1951.

Determination of the reverberation time T [see V. O. Knudsen, *J. acoust. Soc. Amer.* **3**, 1, 126–138, July 1931] furnishes the sound-absorption coefficient α at room temperature of water and aqueous solutions of $MgSO_4$ and other salts in the frequency range from 750 to 1500 kc/s. Allowance is made for viscous damping in the thin layer of liquid near the walls of the container, and an expression obtained for α in terms of T, the dimensions of the cylindrical vessel, the coefficient of viscosity of the liquid at the temperature used, and the frequency f. Results are tabulated for water at 18 and 25 C, the ratio α/f^2 being found constant at each temperature. A 0.04-molar solution of $MgSO_4$ showed an appreciable additional absorption compared to pure water, the ratio α/f^2 increasing rapidly as f was lowered.

Ralph Heller, USA

1080. Hubbard, H. H., A survey of the aircraft-noise problem with special reference to its physical aspects, *NACA TN* 2701, 41 pp., May 1952.

1081. Elwell, F. S., Experiments to determine neighborhood reactions to light airplanes with and without external noise reduction, *NACA TN* 2728, 75 pp., May 1952.

1082. Lassiter, L. W., and Hubbard, H. H., Experimental studies of noise from subsonic jets in still air, *NACA TN* 2757, 35 pp., Aug. 1952.

The studies were made to evaluate some of the effects of parameters such as jet velocity, density, and turbulence level, as well as jet size, on the noise generated by subsonic jets. Most of the tests were conducted with simple model jets so that flow conditions could be closely controlled, and the results are compared with data obtained with a turbojet engine. The noise intensity was found to increase considerably with increases in exit velocity and turbulence level, and by a lesser amount with increases in jet size and exit gas density, with the highest levels being generally observed downstream of the orifice and near the jet boundary. The jet-noise spectrum was found to be a function of jet size and observer's position; the spectrums having a relatively large low-frequency content are associated with the larger jet sizes and locations close to the jet axis.

The noise generated by a turbojet engine is shown to be closely related to that generated by simple model jets, and an empirical relation is given to allow the extrapolation of available jet-noise data to other operating conditions. From authors' summary

1083. Westley, R., and Lilley, G. M., An investigation of the noise field from a small jet and methods for its reduction, *Coll. aero. Cranfield Rep.* 53, 34 pp., 44 figs., Jan. 1952.

One aspect of the problem of jet-engine noise is investigated experimentally by using a 1-in. convergent nozzle through which air flows at about atmospheric temperature and at speeds above and below choking. Detailed measurements are given for the noise level and the spectrum both near to and far from the jet exit. Some of the results are compared with Lighthill's theory and show some agreement with the theoretical prediction that the elementary sound radiator is an acoustic quadrupole. Using dimensional analysis, formulas are obtained for the total sound intensity and for the frequency spectrum at a point in the noise field. To reduce the noise level, a number of simple devices are tested and it is found that the reduction is about 10 decibels for the best device. These results make further investigation desirable. One interesting incidental result is that a wire-gauze extension on the jet nozzle causes the jet, when above choking, to emerge as a supersonic stream free from expansion and shock waves. [Reviewer notes the term $(1 + P)$ appears to have been misprinted $(1 - P)$ in equation 3.5. For results of a related investigation, see preceding review.] Neal Tetervin, USA

1084. McGinnis, C. S., and Albert, V. F., Multiple Helmholtz resonators, *J. acoust. Soc. Amer.* **24**, 4, 374–379, July 1952.

Frequencies of normal modes of vibration have been calculated for configurations of more than two Helmholtz resonators using Lagrange's energy method. Experimental verification is obtained with mechanical systems, which offer a direct method for explaining resonances of the vocal tract. E. G. Fischer, USA

1085. Chester, W., The reflection of a transient pulse by a parabolic cylinder and a paraboloid of revolution, *Quart. J. Mech. appl. Math.* **5**, part 2, 196–205, June 1952.

Solutions are obtained for the incident wave front parallel to

the apex of a rigid obstacle. Approximate forms of the reflected pressure show that the disturbance lies wholly within a cylindrical (or spherical) wave front centered at the focus, a discontinuity in the incident front being reproduced in the reflected front. In fixed directions not parallel to the axis, the discontinuity tends to zero as $r^{-1/2}$ (or r^{-1}), where r is the distance from the focus; at the junction of the incident and reflected wave fronts on the obstacle, the pressure is doubled; at any fixed point, the reflected pressure tends to zero as $t^{-1/2}$ (or t), where t is the time. Comparative plots of the pressure distribution on the boundary for the two obstacles are presented for an incident unit pulse. The results are also of general interest in regard to relations between effects arising from a two-dimensional and the corresponding axially symmetric obstacle.

Vic Twersky, USA

1086. **Lassiter, L. W., Noise from intermittent jet engines and steady-flow jet engines with rough burning,** *NACA TN* 2756, 21 pp., Aug. 1952.

Sound measurements were made on a pulsejet and a subsonic ramjet of the types used for helicopter rotor drive and on a turbojet with afterburner. The pulsejet was found to produce a discrete-frequency spectrum having a single predominant component corresponding to the engine-firing frequency. The angular distribution was slightly directional, with the largest sound pressures occurring to the rear of the engine and near its axis. It was found that an estimate of the noise level from a pulsejet could be made by application of resonant-tube theory, if certain of the average flow parameters of the engine are known or can be reasonably approximated.

The small subsonic ramjet and the turbojet with afterburner were both found to produce discrete-frequency noise spectrums. Their spectrums, however, contrasted with that of the pulsejet in that they contained several harmonic components of magnitude comparable with that of the fundamental.

From author's summary

1087. **Kuhl, W., Measurements in a tank for water-borne sound lined with an absorber** (in German), *Akust. Beihefte* **3**, AB140–AB144, 1952.

The sound field in a measuring tank for water-borne sound lined with an absorber is investigated experimentally and is computed in the frequency range of 4 to 80 kcps.

From author's summary

1088. **Kösters, Angelika, On sound measurements in fluids by the Rayleigh disk** (in German), *Akust. Beihefte* **3**, AB171–AB174, 1952.

There are two ways to correct König's formula for the density of the medium surrounding the Rayleigh disk, which were developed by A. B. Wood and L. V. King, respectively. In order to determine which of these theories agrees best with experiments, two kinds of measurements have been made. The densities of disk material and surrounding liquid have been varied.

Experiments confirm Wood's theory but do not agree with King's, this result having been obtained already by Wood. Reliable measurements can only be made with rigid disks (not able to vibrate like free plates). Otherwise, field distortion will occur which may result in changing the angular rotation of the disk. The rotation does not depend on the viscosity of the surrounding liquid.

From author's summary

1089. **Dingle, R. B., Derivation of the velocity of second sound from Maxwell's equation of transfer,** *Proc. phys. Soc. Lond.* (A) **65**, part 5, 389A, 374–376, May 1952.

From Maxwell's equation of transfer, author derives in a simple way an expression for the velocity of second sound in liquid helium. The reuslt is discussed and compared with Landau's two-fluid theory.

Hans L. Oestreicher, USA

1090. **Markham, J. J., Second-order acoustic fields: relations between density and pressure,** *Phys. Rev.* (2) **86**, 9, 710–711, June 1952.

The author puts the classical energy equation for inviscid nonconducting fluids (which he attributes to Eckart) into the form $\dot{p} = \kappa_s\dot{\rho}/\rho$, where κ_s is the adiabatic bulk modulus. Expanding κ_s/ρ into a series, he shows that the second-order correction to the pressure satisfies a certain partial differential equation. What he calls "the solution of interest" yields the same result as if one assumes $p = f(\rho)$ and truncates the power series after two terms. [While the author claims that his results justify the assumption $p = p(\rho)$ in the usual acoustical treatments of absorption, the reviewer is unable to see that these unjustified manipulations prove or indicate anything at all. Moreover, the assumption $p = p(\rho)$ is neither correct nor necessary in the theory of absorption.]

C. Truesdell, USA

1091. **Markham, J. J., Second-order acoustic fields: energy relations,** *Phys. Rev.* (2) **86**, 9, 712–714, June 1952.

By using various power series truncated after the first one or two terms, neglecting the motion of the medium, the author derives the following formula for the time average of the stored potential energy

$$(\epsilon)_{Av} = \frac{1}{4\rho_0^2}\left\{c^2 - \frac{p_0}{\rho_0}\left[1 + \frac{\rho_0}{c}\frac{\partial c}{\partial \rho}\right]\right\} R^2$$

where R is defined by the assumed solution for the particle velocity ρ [Westervelt, see AMR **4**, Rev. 929]

$$\rho = \frac{1}{\rho_0 k} R \sin(\omega t - kx) + \frac{R^2 x}{2\rho_0^2}\left[1 + \frac{\rho_0}{c}\left(\frac{\partial c}{\partial \rho}\right)\right]\cos^2(\omega t - kx)$$

The author's result contains terms not present in usual expressions.

C. Truesdell, USA

1092. **Gabrielli, I., and Poiani, G., Measurements of the ultrasonic velocity in some mixtures of liquids** (in Italian), *Ric. sci.* **22**, 7, 1426–1432, July 1952.

The method of diffraction of fringes of Lucas and Biquard was used, with ultrasonic frequency of 6.4 megacycles/sec. In the mixtures methyl (or ethyl) alcohol-ethyl ether, the compressibility vs. composition is found to be almost linear.

The common characteristic of the systems cyclohexane-acetone and cyclohexane-ethyl alcohol seems to be the removal of the second component molecules one from the others by cyclohexane. In the mixture aniline-nitrobenzene, one finds an almost linear compressibility curve; while the mixture aniline-ethyl alcohol shows the shape of the compressibility curve of the nitrobenzene-ethyl alcohol system.

From authors' summary

1093. **Dutta, A. K., Ultrasonic absorption and relaxation mechanism,** *Indian J. Phys.* **26**, 6, 279–282, June 1952.

Absorption of elastic waves in liquids is always considered to be the result of some relaxation process. This involves two arbitrary constants A and ν_m. At low frequencies, the ratio of the attenuation in nepers/cm to the square of the frequency is equal to A/ν_m. The complete absorption relation is

$$\alpha/\nu^2 = A/\nu_m = 1/[1 + (\nu/\nu_m)^2]$$

where α is the attenuation in nepers/cm, and ν the frequency. A mechanism, such as the excitation of vibrational or rotational

modes in a liquid, involves a relation between A and ν_m which has not been borne out for such liquids as carbon bisulphide and benzene. It is suggested that ordinary shear viscosity is a relaxation mechanism. However, this was first pointed out by Maxwell, who suggested that the shear viscosity should be relaxed by the shear elasticity of the liquid with a frequency $\nu_m = \mu/2\pi\eta$, where μ is the shear stiffness and η the shear viscosity.

Warren P. Mason, USA

1094. Thaler, W. J., The absorption and dispersion of sound in oxygen as a function of the frequency-pressure ratio, *J. acoust. Soc. Amer.* **24,** 1, 15–18, Jan. 1952.

A single crystal interferometer has been constructed to measure ultrasonic absorption and velocity in gases at high frequency/pressure ratios. Measurements have been carried out in different samples of oxygen of various degrees of purity. The measurements were made at 1 and 2 mc, and extend over an f/p range from 1 to 76 mc/atmosphere. The measurements were taken at or near 30 C. The results indicate the existence of dispersion with a relaxation time of 5.24×10^{-9} sec. This effect is attributed to a rotational relaxation. Reviewer points out that these results are disputed by Parker and Stavseth [*J. acoust. Soc. Amer.* **24,** 456, 1952] who obtained a relaxation time of 0.495×10^{-9}. There is no apparent incorrectness in either method, so that judgment as to the correct value must be suspended.

R. T. Beyer, USA

1095. Schoch, A., Sound transmission through plates (in German), *Acustica* **2,** 1, 1–17, 1952.

The theory of transmission of sound—plane waves and laterally bounded beams—through plates is given in a form which reveals the connection with the free waves in plates. Cremer's interpretation of total transmission as "coincidence" of the incident wave with a free wave in the plate, certain exceptions from that representation, and the influence of the finite cross section of the beam are discussed. The conclusions have been confirmed experimentally on aluminum plates by ultrasonic waves.

From author's summary

Ballistics, Detonics (Explosions)

(See also Revs. 977, 1014)

1096. Szabo, M., On the scattering by shot firing (in Croatian), *Glas. Mat.-Fiz. Astr.* (2) **6,** 4, 155–162, 1951.

Author attempts to give mathematical expressions of the scattering of shot. When firing from a shotgun, the scattering is caused by the action of the powder gases (after leaving the gun barrel) and is called "inherent scattering." Other components of scattering are "air scattering," caused by the resistance of air, and "individual scattering," caused by the differences of the shot. This last component is not treated because usually it is not calculable. In order to compute both the inherent and air scattering, author makes two simplifications: (1) The charge is supposed to be an ideal fluid, and (2) the surfaces of the streamlines in the radial motion are perpendicular to the axis.

Author derives mathematical expressions for both inherent and air scatterings. With these expressions, he calculates the scatterings for 20 and 12-caliber shots. His results agree closely with German standards in the "Deutsche Versuchsanstatt für Handfeuevwaffen E. V. Wannsee: Schrottschussbeurteilung 1937."

It is known that the scattering is greater for the rear shots. This is caused by the greater inherent-scattering component, which is the greatest factor of scattering.

Greater scattering in the smaller calibers is caused principally by both inherent and air components which are inversely proportional to the caliber.

J. Marinković, Yugoslavia

1097. Besse, L., Theory of probability and application to ballistics (in French), *Mém. Artill. fr.* **26,** 2, 381–476, 1952.

Author points out that the material in this tract constitutes an essential supplement to his course in exterior ballistics at the École Normale Supérieure de l'Armament. But the topics treated here are no less essential to engineers in other specialized branches. Author seeks to cover the whole field of probability starting from first principles, using illustrations chiefly from exterior and interior ballistics. The Introduction reviews the theory of Euler's gamma function. The notion of a general probability distribution is made concrete through special mention of the normal distribution, Poisson's distribution, the rectangular distribution, and the chi-square function. Finite probability, including discussion of Bayes' theorem, is used to motivate the inquiry into the continuous case. Dispersion of a system of measurements, cumulation (courbe de répartition), moments, probable errors, both for a single variable and in the plane, Chebíshev's rule, correlation, curves of regression, mathematical expectation, random variables, etc., are treated, as are also the characteristic function of a probability distribution, the moment-generating function, and limiting values as the number of random variables increases.

A. A. Bennett, USA

1098. Carrière, P., Theoretical methods in ballistics (in French), *Actes Coll. Inter. Mécan.* **II.** *Publ. sci. tech. Min. Air, Paris,* no. 250, 7–36, 1951.

Paper is a general survey of the whole field of theoretical ballistics, both interior and exterior. The history of the development of the subject is traced in outline, but even the main contributions are not given in detail. No new material is presented.

In the field of exterior ballistics, the treatment starts from the fundamental equations of motion of a projectile and describes the mathematical methods employed in the investigation of steady flow at supersonic speeds. The drag on the projectile is analyzed into its constituents of wave resistance, function resistance, and the resistance associated with the rear end, and the work of von Kármán and Moore on this subject is briefly described. The equations governing damping of oscillatory motion in a projectile are also given.

In interior ballistics, most attention is given to work published since World War II by the author and others, in which allowance is made for the mass and momentum of the combustion gases themselves so that the classical assumption of uniform pressure in the barrel at any time is no longer true. It is shown that normal dynamic and thermodynamic equations, neglecting viscosity and conductivity, can be employed with fairly simple numerical integrations to give improved values for the theoretical pressure on the projectile and other similar quantities.

D. G. Christopherson, England

1099. Eckel, K., Relation between the perturbation coefficients of ballistic perturbation theory (in German), *ZAMP* **3,** 4, 309–311, July 1952.

Paper deals with the perturbations in a conventional ballistic trajectory due to small changes in initial velocity, gun elevation, ballistic coefficient, or atmospheric temperature. These perturbations can be calculated by the integration of systems of linear differential equations. It is known that the number of necessary integrations can be reduced from four to three by using a set of formulas due to Darrieu and Stanke. Author derives a further set which reduces the number from three to two.

R. Drenick, USA

1100. **Fay, J. A., A mechanical theory of spinning detonation,** *J. chem. Phys.* **20,** 6, 942–950, June 1952.

Spinning detonation in tubes is treated from a hydrodynamic viewpoint by considering a periodic fluid motion in the wake of the detonation wave. Three-dimensional sound theory is used to determine characteristic vibration frequencies. From experimental evidence, author concludes vibrational motion is almost entirely transverse. Natural transverse frequencies compare favorably with frequencies of spin for various tube sizes and mixtures.

Phenomenon is interpreted as self-excited vibration occurring when changes in reaction rate, due to heating and cooling by pressure waves, are great enough to allow accumulation of unburned gas behind the shock front, followed by rapid ignition. During high-pressure period the gas burns rapidly, generating a strong compression wave. The compression wave excites natural vibrations, reinforcing the vibrational mode, the frequency of which corresponds to rate at which combustion may be advanced or retarded by heating or cooling. The crest of the wave, i.e., pressure peak and luminous region, follows a helical path along the wall of a cylindrical tube, as is observed experimentally.

Marjorie W. Evans, USA

1101. **Murgai, M. P., Detonation of proton gas,** *Indian J. Phys.* **26,** 6, 313–316, June 1952.

Hydrodynamic theory of detonation has been applied to proton gas. Due to the very high value of the energy released in the proton-proton reaction, the calculated values of detonation parameters are much greater than those for chemical explosives. Due account of radiation pressure and energy has been taken.

From author's summary by G. Moretti, Argentina

1102. **Tsien, H. S., Adamson, T. C., and Knuth, E. L., Automatic navigation of a long range rocket vehicle,** *J. Amer. Rocket Soc.* **22,** 4, 192–199, July–Aug. 1952.

The control and stability of a winged missile in the equatorial plane of a rotating earth are developed when the normal flight path is changed due to disturbances of the atmosphere and deviations of the vehicle from standard. On the basis of certain assumptions concerning the atmosphere and the properties of the missile, the normal flight path (standard atmosphere, standard vehicle) can be computed by solving the six ballistics equations of motion. The proper cut-off time of rocket power and proper variation of elevator angle are then known before take-off. When the properties of the atmosphere and the vehicle change from standard, ballistic disturbance equations occur, containing coefficients which are variable with time. The solution of these linearized equations yields the basic equation for automatic navigation. A complete system of automatic navigation to obtain zero range error is suggested, based on information from ground-tracking stations and using the vehicle itself to measure the deviations of the atmosphere from standard.

The solution of the disturbance equations with time-variable coefficients represents a novel and remarkable extension of a method suggested by R. Drenick [AMR **4,** Rev. 4325], which is based on the adjoint functions by G. A. Bliss. Authors' solution in curvilinear coordinates can be applied to three-dimensional flight, taking into account curvature and rotation of the earth with flight-path corrections for unlimited types of disturbances. The adjoint functions lead to a transformation of the original disturbance equation into a form in which the solution is easier. Once the equation in adjoint functions is established as the "fundamental formula," it is possible to solve first for the correct cut-off time. Secondly, for the ensuing condition of no thrust, the equations which govern automatic navigation are obtained. The control is achieved only by programming the elevator angle. In the example worked out, the variables chosen include most commonly encountered atmospheric disturbances, i.e., in density and temperature with the corresponding changes in Reynolds number, Mach number, lift, drag, and moment coefficient, further changes in predicted headwind, and also unpredicted changes in weight and moment of inertia of the vehicle, e.g., due to irregular fuel consumption. G. R. Graetzer, USA

1103. **Baumann, M., On a new principle for anti-aircraft sights for the determination of the roof plane of a moving target** (in German), *Flugwehr und Technik* no. 6, 135–138, June 1952.

Assuming the path of the target to be a straight line, it is proposed to represent mechanically the plane which contains that course and the position of the antiaircraft artillery through two sight lines. The first one will be fixed in the device which catches the target, and the second is obtained by pursuing the target. A prototype sight was built for a 20-mm gun. It was tested in practice. H. Schardin, Germany

Soil Mechanics, Seepage

(See also Revs. 842, 843, 994)

1104. **Spangler, M. G., Soil engineering,** Scranton, International Textbook Co., 1951, ix + 458 pp. $6.50.

Book, according to author's preface," is intended for use by undergraduate students. . . and by practicing engineers who may not have had formal training in soils. . . The aim has been to lead the reader through appropriate phases of the basic sciences of geology, pedology, soil physics, and physical chemistry and to illustrate the applications of these sciences in soil mechanics and soil engineering." Book is written in textbook form with numerous line drawings and illustrative problems interspersed throughout; a list of problems is given at the end of each chapter.

Chapters are presented on nearly all phases of soil mechanics, such as soil moisture, classification, shearing strength, consolidation, and bearing capacity, to mention a few. Subjects are not treated exhaustively, but general basic information is given in all cases. Reviewer has distinct impression that book is slanted toward highway-engineering practice.

Excellent introduction is given to origin and nature of soil, stressing pedological features; this chapter covers a field not adequately treated in many soil-mechanics texts. Good discussion is presented of several types of soil moisture and their influence on soils-engineering problems. The final chapter, on underground conduits, on which author is a recognized authority, gives good treatment to a subject of importance which is often neglected in soils engineering. Chapter on soil surveying and sampling is weak and does not cover best up-to-date practice in this field. In many cases throughout text, author presents methods of analysis without adequately describing the limitations of application and without indicating other methods, not described, which may be used; however, this may not be of great importance to audience for which book was written.

Reviewer believes book is worthy of inclusion in soil-engineer's library on basis of good treatment of subjects discussed above.

Woodland G. Shockley, USA

1105. **Reeve, R. C., and Kirkham, D., Soil anisotropy and some field methods for measuring permeability,** *Trans. Amer. geophys. Un.* **32,** 4, 582–590, Aug. 1951.

Three field methods for measuring permeability of water-saturated soils below a water table are investigated: Piezometer, tube, and auger-hole method. All have in common that, first, a

cavity is made in the soil with a minimum of disturbance; this is allowed to fill with water, which is pumped out, and the rate of rise is observed. In the piezometer method, water seeps into a cylindrical cavity through the base and part of length of a thin tube; in the tube method, water seeps upward only over a horizontal surface; as to the auger-hole method, the entrance of water occurs on the sides and bottom of an uncased auger hole. The diameters of tubes in the three methods were 1 in., 8 in., and 4 in., respectively. The size of soil mass affecting the results associated with each method differs considerably.

Test results of two sites with these methods and the usual undisturbed core testing are presented, with evaluation of the measured data using authors' formulas. Following conclusions are drawn: Soil anisotropy—permeability much greater in horizontal than in vertical directions—effects results in the three methods differently, because the manner in which flow enters the cavities is different. In the piezometer method, permeability decreases with increasing ratio of tube radius R to length of cavity L, the effect of horizontal flow toward the cavity becoming more important. With a small value of R/L, the true horizontal permeability can be measured. In the tube method, the measured value will be close to the true vertical permeability. Thus, using both methods, information on soil anisotropy can be obtained.

Effect of root holes is then considered both in the field and laboratory measurements; it may be minimized by increasing the diameter of the piezometers. Authors believe that root holes caused the apparent decrease of permeability with decreasing hydraulic head. In presence of root holes, laboratory methods do not give reliable results; in this case, auger-hole method appears particularly advantageous. Árpád Kézdi, Hungary

1106. Terzaghi, K., and Richart, F. E., Jr., Stresses in rock about cavities, *Géotechnique, Lond.* **3**, **2**, 57–90, June 1952.

Paper gives a comprehensive survey and evaluation of available analytical and experimental information on stress distribution in rock around the following types of cavities: Straight tunnels with elliptical cross section; straight tunnels with circular cross section; spherical cavities; oblate spheroidal cavities. For latter problem, original solution is developed. Recent experimental stress-determination procedures are critically examined; uncertainties due to unknown stress condition in undisturbed rock mass are pointed out. O. Hoffman, USA

1107. Labasse, H., Soil pressure in coal mines. VII. Mechanics of extended layers (in French), *Rev. univ. Min.* (9) **8**, 7, 251–264, July 1952.

This paper forms the 7th part of author's investigations [AMR **2**, Revs. 1332, 1333; **4**, Revs. 2273, 3077]. The deformations in the strata above worked seams are analyzed. Author deduces angle of internal friction of overburden from angle of draw, using Coulomb's theory of earth pressure. This procedure is not admissible because deformation conditions of that theory are not satisfied here. G. G. Meyerhof, England

1108. Costello, R. D., Damping of water waves by vertical circular cylinders, *Trans. Amer. geophys. Un.* **33**, 4, 513–519, Aug. 1952.

The results of this series of model experiments indicate that the relative depth parameter d/L may be neglected in the comparison of various transmission capacities. A maximum damping of waves, resulting in a wave transmission of 42% of the incident wave height, was obtained with a relatively dense configuration of 48 rows of $^3/_8$-in.-diam cylinders rectangularly arrayed and spaced one inch center-to-center. It was noted, within the limits of experimentation, that increasing the number of rows by 100% resulted in an average decrease in wave transmission of only 18%, irrespective of the density and configuration of the cylinders. Progressive wave-height measurements through a dense cylinder configuration (rectangular array with one-inch center-to-center spacing) showed that between 40 and 80% of the total decrease in wave transmission occurs within the first $^1/_5$ of the length of the structure. More generally, it may be stated that approximately 50% of the total decrease in wave transmission occurs within the structure a distance, from the seaward face, of less than $^1/_4$ of the wave length. The over-all results of the experiments show rather conclusively that a moderately dense piled structure is highly selective in its capacity to reduce wave action. Its ultimate transmission capacity for a given test section depends upon the magnitude of the incident wave steepness.

From author's summary

1109. Geuze, E. C. W. A., Lectures by, (1) Foundation problems in western Holland. (2) Solution of foundation problems by means of soil research. (3) The stability of dikes under the effect of interstitial water (in Spanish), *Inst. tecn. Constr. Cem. Publ.* no. 114, 45 pp., May 1952.

Paper is the transcription of three lectures. First, author presents the Dutch problem of foundations, with very soft soils and only sand strata to support heavy loads. Foundations with piles are very common in Holland and much experience is acquired with this technique. Author reviews modern methods to determine maximum load of each pile. In the second lecture, he presents modern developments in soil testing used in Holland, mainly concerning piling, and describes devices for constant velocity of penetration testing. Several results are given. In the third lecture, author studies stability of earth dams and embankments against loads and pore pressure, and refers to the triaxial method of soil testing. Finally, electrical drainage or electroosmotic methods of solution for percolation problems are treated.

Reviewer thinks that this transcription would be more useful if author would extend the paper with more data and details than are required by a lecture. A. Balloffet, Argentina

1110. Mikhaĭlov, G. K., On the problem of seepage in anisotropic earth dams with trapezoidal profile on a horizontal impermeable base (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **80**, 4, 553–556, Oct. 1951.

Author assumes as known the solution by Dupuit and Pavlovski for discharge through triangular dam with vertical upstream face, partially filled (or thoroughly filled trapezoidal dam). Discharge in this solution is put in relation to discharge through a filled dam (which is product of permeability coefficient and squared height divided by base width). Author proves mathematically that the slopes of the discharge face, as well as the change of permeability coefficient in vertical direction, have practically no influence. In a graph, relations between discharge through a dam when partially filled and when thoroughly filled are given. Influence of the slope of upstream face is introduced as supplement. V. Mencl, Czechoslovakia

1111. Sokolovskiĭ, V. V., Theory of limit equilibrium of soils and its application to the analysis of hydrotechnical structures (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 6, 809–823, June 1952.

Paper presents an outline of application of the theory of limit equilibrium to solution of some two-dimensional stress problems in soil structures. Limiting state of stress is assumed at all points, and it is represented by the two differential equations of

equilibrium and by the ordinary equation of limiting state, involving constant coefficients of friction and cohesion. Transformation, particulars of which are not given, reduces these equations to canonical system of equations in which the two independent variables are parameters characterizing the curves belonging to the two families of sliding surfaces. The resultant equations are applied to several problems resembling the conditions existing in foundations, unretained slopes, and retaining walls. The details of solutions are not given, but some explicit formulas resulting from them are presented. Special cases of soils free either from cohesion or from friction are also considered. Reference is made to the inelastic state of equilibrium preceding the limiting state, under some simplified stress-strain assumptions.

A. Hrennikoff, Canada

1112. **Casagrande, A., and Shannon, W. L., with discussion by Barber, E. S., Krynine, D. P., Casagrande, A., and Shannon, W. L., Base course drainage for airport pavements,** *Trans. Amer. Soc. civ. Engrs.* **117,** 792–820, 1952.

Field data from five sites show the saturation of base courses from infiltration through pavements and by frost action. An approximate formula for lateral drainage of an initially saturated base course is derived and checked with models, using glycerine between parallel glass plates, and full-scale test sections. The results are summarized in recommendations for design of base drainage.

E. S. Barber, USA

1113. **Kist, A. P. F., The triaxial compression test, as applied to the investigation of bituminous sands** (in Dutch), *Ingenieur* **64,** 32, B.137–B.142, Aug. 1952.

In the introduction, attention is called to the triaxial compression test for dense bituminous aggregates, as developed by L. W. Nijboer ["Plasticity as a factor in the design of dense bituminous road carpets," Elsevier Publishing Co., Inc., New York, Amsterdam, London, Brussels]. After a description of the triaxial compression apparatus, details are given concerning tests on bituminous sands (without filler), and with or without addition of rubber (Pulvatex).

When compacted under similar conditions, bituminous sand mixtures with rubber retain a greater voids percentage than mixtures without rubber. Addition of rubber increases the cohesion and does not alter the angle of internal friction, whereas a lower penetration of the bitumen increases cohesion while slightly diminishing the angle of internal friction. Independent of rubber addition or the hardness of the bitumen, the optimum bitumen percentage was found to be 5 to 6% of the dry weight of mineral aggregate.

From author's summary

1114. **Larew, H. G., Use of field, laboratory and theoretical procedures for analyzing landslides,** *Nat. Res. Counc., Highway Res. Bd. Bull.* 49, 28–39, 1952.

Paper presents field and laboratory data obtained from three actual landslides. The study was confined to a two-dimensional analysis of a shear-type failure in shallow deposits of unconsolidated materials. The data were used to check the validity of the circular-arc method of slope analysis. The soil strength required for stability, as determined from this method of analysis, was compared with the strength of the soil as measured by laboratory tests. The data are insufficient to indicate definitely the range of applicability of the circular-arc method. However, when combined with similar data from previous studies, the results indicate the limited applicability of this approach and point to the area where further study is needed before it can be used to obtain quantitative answers to the problem of prevention and correction of highway landslides.

From author's summary

1115. **Wieghardt, K., On some experiments with flow in sand** (in German), *Ing.-Arch.* **20,** 2, 109–115, 1952.

Some simple tests of the flow of sand are described. Ordinarily, in soil mechanics the main interest is in statics, but some dynamic tests are here presented. Initial tests were on various mixtures of sand and water, but principal tests were on two grades of dry sand, one fine and one coarse.

In one series, a bucket of sand was fastened to a motor-driven horizontal turntable. The torque was measured in the test range of 20 to 60 rpm, and it was reported for various cylinders and cones immersed to several depths at the center of the bucket. These data can be used to determine coefficients of friction. A second series was performed for vertical and horizontal cylinders immersed off center in the bucket.

For a third series, the discharge of sand through a small hole in a thin plate at the bottom of a tube was measured. This was a study similar to the ancient hourglass. Rate of discharge of coarse and fine sand through holes of several diameters was measured. Finally, the tests were repeated for the tube inclined at an angle to the axis. Further research is suggested.

M. W. Jackson, USA

1116. **Rogers, F. T., Jr., and Morrison, H. L., Remarks on the theory for convection in porous media,** Heat Transfer Fluid Mech. Inst., Stanford Univ. Press, 45–52, 1951. $5.

Paper describes the prior work done pertaining to theory to explain the occurrence of convective flow of a fluid in a porous medium due to a critical thermal gradient. Such a theory was developed by a direct adaptation of Rayleigh's work, which did not contemplate flow in a porous medium and was obtained merely by introducing Darcy's law. Consequently, the theory assumed constant viscosity and also linear variations of temperature with vertical distance in the medium.

Authors suggest a method for extending the theory to allow for nonconstant viscosity and nonconstant vertical thermal gradients. They also indicate that this method permits an evaluation of one formula for critical thermal gradients which not only applies to both the low-gradient and high-gradient regimes, but also holds for intermediate values of thermal gradient.

Julius Aronofsky, USA

Micromeritics

(See also Rev. 711)

1117. **Lamar, R. S., A review of methods for determining particle size distribution of ceramic raw materials,** *Amer. ceram. Soc. Bull.* **31,** 8, 283–288, Aug. 1952.

A general discussion of a number of methods for determining particle-size distribution and specific surface is given. Laboratory procedures, inherent inaccuracies, and size ranges covered by each method are discussed.

From author's summary by G. H. Lean, England

1118. **West, W. J., Size determinations of clay particles in water suspensions by use of low-angle x-ray diffraction,** *J. Colloid Sci.* **7,** 3, 295–305, June 1952.

An x-ray method for ascertaining sizes of particles in muds and thick-clay suspensions is described. The equation is derived for spherical particles in dilute suspensions, but its extension to platelets in gels is not clear. Author finds that, in the transformation of a dry clay powder to a clay-water gel, the particle size increases, which is contrary to current belief. If valid, the method should prove very fruitful.

Hans Jenny, USA

1119. Richardson, E. G., Behaviour of aerosols in acoustic and turbulent fields, *Acustica* **2,** 4, 141–147, 1952.

Paper describes experiments concerning the effects of acoustic and turbulent fields on the rate of coagulation of aerosols.

From author's summary

1120. Noss, P., Measuring methods and measuring instruments for the determination of dust content in flowing gases (in German), *Brennstoff-Wärme-Kraft* **4,** 7, 227–233, July 1952.

Author considers mainly flue gases of boiler installations. He discusses sampling by sucking off a part of the dust-laden flue gas, filtering the dust from this side stream, measuring its flow rate, and the commercial apparatus in common use for these purposes. The effect of errors in dust measurement on the determination of efficiency of dust separators is considered.

J. O. Hinze, Holland

Geophysics, Meteorology, Oceanography

(See also Revs. 713, 761, 764, 1108)

1121. White, R. M., and Cooley, D. S., The large-scale vertical eddy stress in the free atmosphere, *Trans. Amer. geophys. Un.* **33,** 4, 502–506, Aug. 1952.

An attempt is made to determine the order of magnitude of the large-scale vertical eddy flux of angular momentum in the free atmosphere for the middle latitude region 30 N to 60 N. It is suggested that a significant portion of the vertical flux may be transported downward by vertical eddies associated with migratory cyclones and anticyclones in middle latitudes.

From authors' summary by W. W. Berning, USA

1122. Hinkelmann, K., The mechanism of meteorological noise (in German), *Tellus* **3,** 4, 285–296, Nov. 1951.

The difference between the solutions of the primitive hydrodynamic equations and the quasistatic (quasigeostrophic) equations is illustrated by using a simple model. The results show that the solution of the quasistatic equations gives only the large-scale, weather-producing processes, which depend upon the initial pressure field alone, while that of the primitive equations involves also the short period "noises," and depends upon the initial ageostrophic winds. Author also concludes that, from numerical integration viewpoint, primitive equations are mathematically simpler than the quasistatic equations, because the instantaneous rate of change can be computed from the initial data without solving a differential equation. The only requirement is that the time interval used should be small enough. It seems to reviewer that the same method can also be applied to the quasigeostrophic equations.

H.-L. Kuo, USA

1123. Oi, M., Air current crossing a mountain range, *J. Meteor. Soc. Japan* (2) **30,** 6, 183–189, June 1952.

Considering the air current crossing a mountain range to be incompressible and irrotational, author finds that the vertical influences are greater than usually expected, while the horizontal effect is considerably larger. Author believes that his results can be applied to explain westerly wave formations, as well as the origin of jet streams.

P. F. Byrd, USA

1124. Dronkers, J. J., Tidal calculations. I, II (in Dutch), *Ingenieur* **63,** 40, 44: B.137–B.145, B.155–B.164; Oct., Nov. 1951.

Author exposes the technical plan, based on results of tidal calculations, for the enclosure of the tidal river Brielsche Maas and Botlek, on both sides. This technical plan was chosen to insure that the currents in the gaps during the enclosure would be as small as possible. Author develops the equations (motion and continuity equations) for the Brielsche Maas, and the results of the calculation are compared with measurements taken during the enclosure.

In the second part of the paper, author treats tidal calculations more generally. He develops his iteration method of tidal calculation of an estuary (river system).

To get the most from this paper, author's previous paper [AMR **1,** Rev. 558] should be read.

L. J. Tison, Belgium

1125. Larras, J., The turning of the swell around jetties (in French), *Ann. Ponts Chauss.* **122,** 5, 517–523, Sept./Oct. 1952.

Author proposes a new formula for computation of swell amplitudes behind jetties for current needs in port engineering. The formula of Sommerfeld, introduced and checked by Putnam and Arthur [*Trans. Amer. geophys. Un.*, Aug. 1948], is considered too complicated. Author's formula is an approximation by functions simple enough for practical use. Comparison with formulas proposed by others is given.

H. J. Schoemaker, Holland

1126. Weenink, M. P. H., and Groen, P., On the computation of ocean surface current velocities in the equatorial regions from wind data, *Proc. k. Ned. Akad. Wet.* (*B*) **55,** 3, 239–246, May/June 1952.

Previous studies compute total mass transport of currents; authors give method for computing surface velocities, which are easier to check observationally.

Henry Stommel, USA

1127. Lewis, W., and Bergrun, N. R., Probability analysis of the meteorological factors conducive to aircraft icing in the United States, *NACA TN* 2738, 93 pp., July 1952.

Meteorological icing data obtained in flight in the United States are analyzed statistically for the determination of the liquid-water content, drop diameter, and temperature having equal probability of being exceeded in flight. Methods presented are useful in the design of anti-icing equipment intended to operate throughout the United States. A mathematical basis is provided for future statistical analysis of meteorological icing data that might be obtained throughout the world.

From authors' summary by M. Tribus, USA

1128. Saxov, S., The variation of gravity within the earth, *Tellus* **4,** 2, 138–140, May 1952.

Considering the earth as a sphere made up of concentric strata, author uses method of Olczak, F. [*Acta Astronomica* (*C*) **3,** 81–85, 1938] to find recursion formula for the gravitational attraction of a given concentric shell bounded by the radii r_0 and r. The density in any given shell is assumed to be constant; however, it is variable from shell to shell. This is to say, g is function of density of strata as well as depth of strata.

Recursion formula is then applied to Ramsay's density values [*Geoph. Supp. Monthly Notices of the R.A.S.* **5,** 409–426, 1949], it is believed, for first time. Contrary to computations made in two previous papers by other authors, present formula gives (using Ramsay's density values) a surface value of 982 gal with no arbitrary density corrections necessary.

W. R. Griffin, USA

1129. Yosida, Z., On the diurnal variation of air- and ground-temperature on a clear day, *Geophys. Mag., Tokyo,* **23,** 4, 415–422, May 1952.

Author considers the balance, at the surface of the earth, between radiation energy received from the sun and energy used to heat the ground, the air, and to vaporize the water. He assumes that heat transferred to the air, and heat used to vaporize the

water are both proportional to the temperature difference between the ground and "upper boundary of the surface air layer on the ground." With this questionable assumption, the problem of heat transfer from an aerodynamically rough surface (of the earth) to the turbulent boundary layer is reduced to a problem in heat conduction, and solutions are given for harmonic variation in time of the radiation energy received from the sun.

M. S. Uberoi, USA

1130. **Yih, C. S., Similarity solution of a specialized diffusion equation,** *Trans. Amer. geophys. Un.* **33,** 3, 356–360, June 1952.

With the assumptions that the wind velocity over a surface varies as the height y from the surface raised to the power m, that the diffusion coefficient in the vertical direction varies as y raised to the power n, that the diffusion coefficient in the lateral direction varies as y raised to the power k, that the velocity and the diffusion coefficients at a fixed reference distance from the surface are constants, and that the diffusion in the direction of x, the distance along the surface, is negligible with respect to the diffusion in the vertical and lateral directions, the steady-state equation of diffusion becomes

$$y^m \frac{\partial c}{\partial x} = D_1 \frac{\partial}{\partial y}\left(y^n \frac{\partial c}{\partial y}\right) + D_2 y^k \frac{\partial^2 c}{\partial z^2}$$

where z is measured in the lateral direction, c is the vapor concentration at a point, and D_1, D_2, m, n, and k are constants. This diffusion equation is solved exactly for the case $m = k$; use is made of dimensional analysis in obtaining the solution. The solution represents the atmospheric diffusion from a point source when the wind velocity and the vertical and lateral exchange coefficients are power functions of the height.

Neal Tetervin, USA

1131. **Stümke, H., On the calculation of pressure tendency with heat supply within an isothermic atmosphere of constant ground velocity** (in German), *ZAMM* **32,** 2/3, 68–75, Feb./Mar. 1952.

Author proposes a method of "mean" changes of state to compute the development of the weather. Applied to the problem mentioned in the title, the method leads to an elliptical differential equation for the local pressure tendency depending on three parameters (latitude, temperature, and fundamental velocity). If the ground is supposed plane, the problem is solved for the half space by the aid of Green's function. Contrary to the case of the initially resting atmosphere, a new term appears in the energy balance that represents the change of the kinetic energy and is of meteorological importance. From author's summary

1132. **Queney, P., Atmospheric waves considered as associated with vorticity discontinuities** (in French, long English summary), *Tellus* **4,** 2, 88–111, May 1952.

Essentially a study of barotropic zonal flow in which there are latitudes where the vorticity is discontinuous, for instance, in the middle of a jet. If the number of waves girdling the earth is integral for a simple jet of two currents side by side with uniform vorticity in each, the waves are stable; but unstable waves occur when there are two or more parallel jets.

Eddy viscosity has a negligible effect. Stationary waves can loosely explain semipermanent centers of action, and cyclone waves are thought of as unstable waves occurring where a jet is deformed by a local increase in the drag of the ground. This may be caused by thermal instability, but author does not consider the effect of heating which must accompany the drag in such a case.

Some speculations are made concerning various influences which might lead to instability of a barotropic jet.

R. S. Scorer, England

1133. **Ichiye, T., Theory of oceanic turbulence,** *Ocean. Mag., Tokyo* **3,** 3, 83–87, Sept. 1951.

Formal discussion of turbulence spectrum resulting from disturbing forces which also have a spectrum.

H. Stommel, USA

Lubrication; Bearings; Wear

1134. **Wilcock, D. F., and Rosenblatt, M., Oil flow, key factor in sleeve-bearing performance,** *Trans. ASME* **74,** 5, 849–866, July 1952.

See AMR **5,** Rev. 1590.

1135. **Macks, E. F., and Nemeth, Z., Lubrication and cooling studies of cylindrical-roller bearings at high speeds,** *NACA Rep.* 1064, 15 pp., 1952.

See AMR **5,** Rev. 3062.

1136. **Charnes, A., and Saibel, E., On the solution of the Reynolds equation for slider-bearing lubrication—I,** *Trans. ASME* **74,** 5, 867–873, July 1952.

See AMR **5,** Rev. 1594.

1137. **Tourret, R., and White, N., Aeration and foaming in lubricating oil systems,** *Aircr. Engng.* **24,** 279, 122–130, 137, May 1952.

Paper gives a broad picture of the circumstances governing the formation of foams in lubricating systems, with particular reference to aircraft engines. The basic physics of the foam-formation process is discussed first, and the effects of solubility, surface tension, and buoyancy are considered briefly. The various stages in the formation and decay of an oil form are described qualitatively, and the effects of viscosity and temperature on the rate of formation are discussed. The second part of paper relates to the influence on foam formation of design factors in the lubricating system itself. The effect of tank size and of pipe design is considered, and various means of improving the de-aeration characteristic of a given system are suggested. Results of tests on the effect of various detergent additives in increasing the initial foaming volume are also quoted, together with some discussion of the effectiveness and limitations of chemical antifoaming agents.

Paper is, in the main, a survey of the literature of this somewhat neglected subject, and 38 references to original contributions are given. D. G. Christopherson, England

1138. **Kleimon, E., Friction phenomena in conical bearings and their measurement** (in German), *Feingerätetechnik* **1,** 3, 109–113, June 1952.

The theories of friction of Holm and Kluge are reviewed, and a method of measuring the friction occurring in the type of jewel bearing used in electricity meters is described. The sensitivity claimed for the method is such that differences in frictional moment of 0.5×10^{-3} mg cm can be detected.

F. T. Barwell, Scotland

Marine Engineering Problems

(See also Revs. 760, 1030)

1139. **Van Manen, J. D., Design diagrams for 2-, 3-, 4-, and 5-blade propellers calculated according to the circulation theory** (in Dutch), *Schip en Werf* **19,** 10, 11; 203–210, 228–234; May 1952.

From Wageningen B-series propeller diagrams, author first calculates relation between velocity coefficient, ideal thrust con-

stant, and ideal propeller efficiency at diameter of maximum efficiency to be used for calculating propellers for homogeneous velocity field according to circulation theory. Pressure minimums for securing freedom from cavitation are calculated with certain choice of blade-thickness ratio, and for von Kármán-Trefftz sections for shock-free entrance at blade tips. Comparison of ideal efficiency from circulation theory with real efficiency from Wageningen propeller series gives frictional efficiency as function of pitch and area ratios with blade number as parameter.

As an example, calculation has been carried through for a twin-screw passenger ship with 23 knots speed, 17,500 hp per shaft, and 120 rpm. For optimum diameters, two-bladed propeller would have 3.7% better efficiency with 7.3% larger diameter and 14% heavier weight than three-bladed propeller. If diameters are chosen same as optimum for three-bladed propeller, two-bladed one would have 1.7% better efficiency than three-bladed one.

Tests had been made with model of a twin-screw cargo ship with 17.11 knots speed, 4000 hp per shaft, and 300 rpm. With same diameter, two-bladed propeller showed 1.2% better thrust coefficient with 5.3% less weight than three-bladed propeller. G. Vedeler, Norway

1140. Carlotti, P., A note on new forms for ships' sterns, *Trans. Instn. nav. Arch. Lond.* **93,** 1–14, 1951.

The original idea of this paper lies in finding a design which allows placing a contrapropeller and the screw outside the boundary layer which envelops the hull, and also outside the stream of turbulent flow which follows the hull. The after portion of the hull is like a "spoon back," entirely convex and without a sternpost, while a "second hull" (like an engine nacelle in an airplane wing) juts out under the spoon back and supports the propeller shaft. If the surface of the second hull forms spiral flutes, it also serves as a contrapropeller. A theory is given for predicting the behavior of a ship from data from model tests. Comparisons are made of the power requirements for two ships with normal stern posts and similar ships with spoon-back sterns and second hulls. An appendix discusses vortex theory. Marshall Holt, USA

1141. Adams, H. J., Notes on stresses in tanker members, *Trans. Instn. nav. Arch. Lond.* **92,** 3, 262–281, July 1950.

The Hardy Cross method of moment distribution on frame rings is applied to the transverse frame rings of two modern tankers for several conditions of loading and draught. The variation of moment of inertia and section modulus over the length of the members is taken into account, and curves of bending moment and stress distribution are drawn for each member. Positions of peak stress are clearly brought out. The methods used for obtaining the carry-over factor and the stiffness of each member and for calculating the fixed end moments are indicated in appendixes to the paper. From author's summary

1142. Hadjispyrou, A. G., and Lackenby, H., Ship structural members. Part V, *Trans. Instn. Engrs. Shipb. Scotland* **95,** part 7, 563–608, 1951/52.

Paper is fifth in series on strength and stiffness of various ship structural members subjected to selected service loadings as determined from experimental investigations by British Shipbuilding Research Association. In this part, results are given of tests of stiffened plating subject to transverse bending. Full-scale models tested comprised three identical stiffeners with 24-in. spacings on plating 0.40 in. thick and 72 in. wide with total span of 16 ft. Four different stiffeners were employed: Channels and bulb angles riveted to plating; T bars and flanged plates welded to plating. Variations were also introduced in type and size of end connections and brackets and in scallops and slots in webs of stiffeners.

Two tests were carried to destruction, but the remaining were limited to the elastic range of material. Relative merits of different designs are compared, and results presented in form suitable for application in shipbuilding industry. Important results indicate faying flange is not a contributor to strength, and that scallops or slots, while benefiting thermal insulation of stiffened plating, are nevertheless accompanied by an increase in stress in stiffener.

Although experiments appear to have been carefully conducted and comprehensive in scope, analysis of results is not sufficiently complete to permit comparison with theory or generalization for structural design criteria. Edward Wenk, USA

1143. Vedeler, G., Side sway and torsion of ships, *K. norske Vidensk. Selsk. Skr.* no. 2, 51 pp., 1951.

In first chapter, author extends work of his paper [AMR 4, Rev. 3184] which represented application of method of primary moments developed by Efsen ["Die Methode der primären Momente," 1931]. This method, which is based on properties of the elastic line, is now applied to frameworks representative of ship's section asymmetrically loaded and therefore subject to sidesway. A simplified approach is developed on basis of geometric symmetry. Method is restricted to prismatic members; however, extension to include members of variable section, brackets, etc., is possible. In this application, method of primary moments appears superior to the Cross method of moment distribution, because of rapidity of convergence.

In second chapter, theory of torsion of ships is developed beyond author's original work, "The torsion of ships" [*Trans. Instn. nav. Arch. Lond.*, 1924]. Two refinements are introduced: (a) Effect of distortion of sections on torsional stresses; (b) bending induced by torsion. Method is restricted to bodies of constant section. Author finds that, for ships of normal proportions, torsional problems are not very important and that both the foregoing refinements introduce, at most, only small corrections to the simpler approach. He succeeds in showing that bodies of closed sections have no shear center. Author concludes that successful application of ordinary bending theory to complicated structure of ships results from smallness of torsional distortion. M. St. Denis, USA

1144. Nordström, H. F., Edstrand, H., and Lindgren, H., Model tests with icebreakers, *Medd. SkeppsProvAnst. Göteborg* no. 20, 56 pp., 1952.

This is a report of experiments run by the Swedish State Shipbuilding Experimental Tank on ice breakers. It covers self-propulsion and towing tests on a triple-screw (two propeller aft and one forward) and a quadruple-screw (two forward and two aft) ship. Attention is given to flow patterns and to different methods of powering and the resulting influence on the ice-breaking process. F. E. Reed, USA